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CONTENTS.

LOCOMOTIVE DESIGN.*

By F. J. Cole, Mechanical Engineer, Rogers Locomotive Works.

Firebox Crown Stays.

In this article various forms of the supporting stays or bracing for firebox crown sheets will be considered. The possibility of a crown sheet becoming over-heated by the temporary absence of the usual covering of water requires the supporting bolts or stays to be designed with a larger factor of safety than the water space stays, which are wholly below the level of the crown sheet, and for that reason always entirely submerged.

It is not meant by this that the bolts should be made so large and strong that no amount of over-heating would cause the crown sheet to be blown down. A few moments' consideration would show the fallacy of this. It is good practice, however, to provide a very large margin against any temporary absences of water or over-heating either wholly or in part, caused by: (a) foaming; (b) the application of brakes to a swiftly moving locomotive in momentarily exposing or nearly exposing the crown sheet; (c) by improperly or insufficiently admitting feed water to the boiler, which allows the water level to be so lowered that the intense heat generated in the firebox is not absorbed fast enough to keep the sheet at the usual comparatively low temperature; (d) overheating caused by deposit of scale or mud. The action of the brakes in reducing the water level at the back end is more noticeable in straight topped radial stay or Belpaire boilers than in those having wagon tops. Boilers with straight tops have more steam room in the front and therefore greater space for the water to rush ahead when the motion of the boiler is suddenly retarded.

Experience indicates that certain sizes of crown stays give satisfactory results for a given spacing and steam pressure. Also that the upper ends of the bolts or stays may be safely made smaller than the lower ends or parts exposed directly to the heat of the fire. For radial stay and Belpaire boilers 3,500 pounds as an average with a range from 3,000 to 4,000 pounds per square inch of net section will be found a perfectly safe and satisfactory stress for the lower ends, which pass through the crown sheet and are exposed to the action of flame and heat and 5,000 pounds as an average with a range from 4,500 to 5,500 pounds for the upper ends not exposed to flame and heat. For crown bar staying, the fiber stress for the bolts securing the crown sheet to the bars may be safely increased to 4,500 pounds for the lower end, which is exposed to the direct action of flame and heat; and the upper end not exposed to flame and heat to 7,000 pounds of net area.

In Fig. 1 is shown an excellent form of solid button head bolt suitable for radial stay or Belpaire boilers. This form is largely used and makes a first class stay when properly fitted. The lower threaded end is tapered slightly and enlarged about 5/32 of an inch, or just enough to allow the upper end to pass through the lower hole after it is tapped out. The under side of the head is turned true and grooved so that the bearing is on the outside, and the crown sheet spot faced with a cutter, which is provided with a long shank to pass through the inner and outer holes. The diameter of the cutter is not much larger than the bolt head and is arranged to face off the sheet exactly at right angles to the longitudinal axis of the bolts. If this is properly done, the bolt may be screwed in and a steam-tight joint made without bending it under the head, which would otherwise occur, if the holes were not true with the surface of the sheet. See Fig. 2. During the operation of screwing in such a bolt, the head of which touches the sheet at only one point, the neck is alternately bent backwards and forwards at each half revolution until the head is in contact all around. Many instances have been observed in bolts removed from boilers where this repeated bending had caused dangerous cracks just under the head. This is especially the case where the necks had been grooved to facilitate cutting the threads. See tests, numbers 7 to 10 in the table of Record of Tests.

A number of experiments were made by the writer a few years ago to determine the holding power of various forms of firebox crown stays, both hot and cold, with a view to reduce the number of dropped or "bagged" crown sheets. These tests and the conclusions deduced therefrom were published at length in the transactions of the American Society of Mechanical Engineers, May, 1897. A few extracts are given below:

The object in view was to test them as nearly as possible under the same conditions as in actual service, when used in staying the firebox crown sheet of a locomotive, and particularly to note the relative decrease of the holding power at high temperatures. In all these tests, it is assumed that the bolts are spaced 4 by 4 inches, center to center, supporting an area of 16 square inches.

The pocketing, or bagging down, which is characteristic of an overheated crown sheet caused by low water, was imitated by using a bearing plate of ½-inch steel, 8 by 8 inches square, with a hole 4½ inches in diameter bored through its center. The area of this hole is 15.9 square inches. The specimens were screwed or driven into pieces of ⅜-inch steel plate, 12 by 12 inches square.

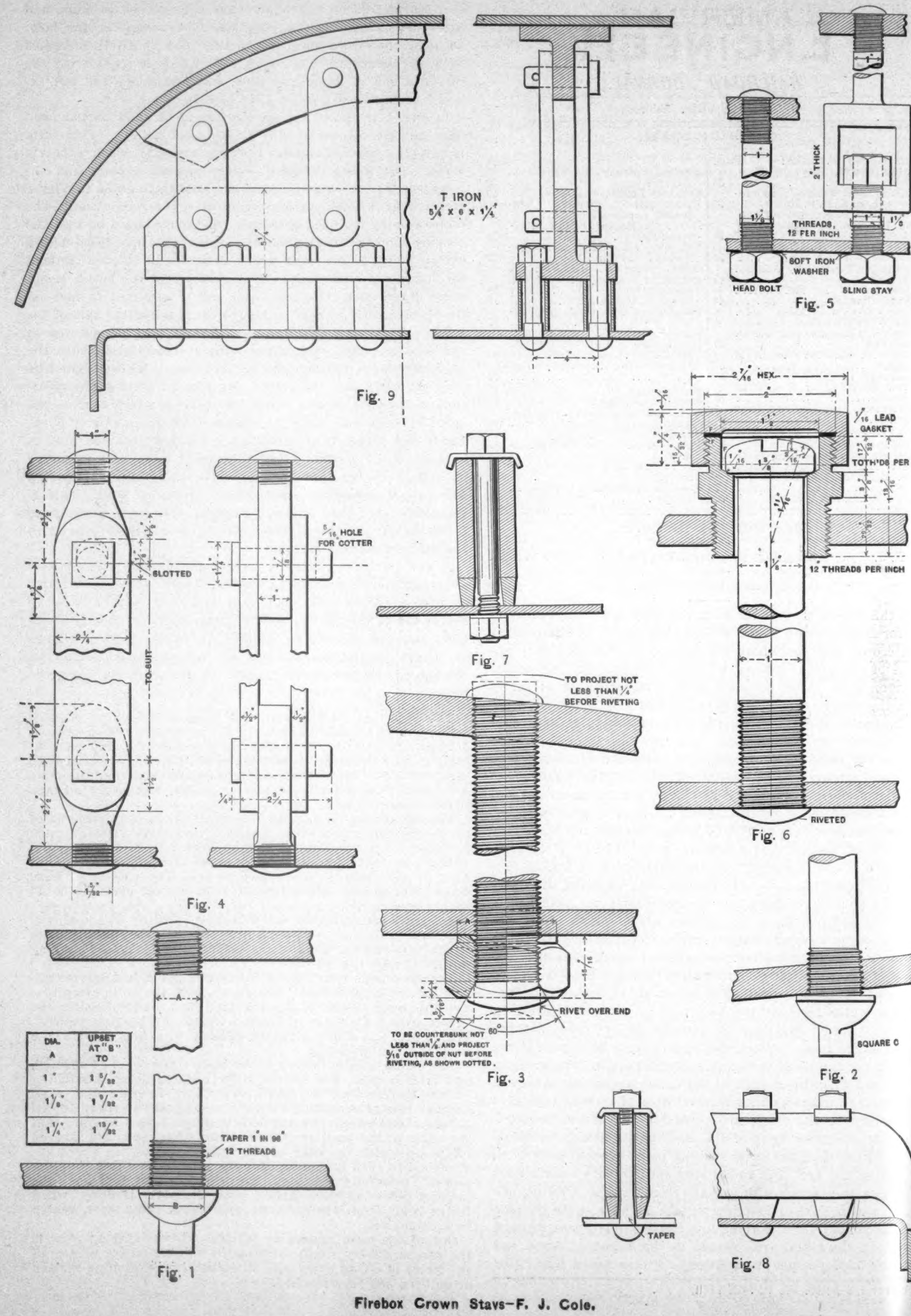
A 100,000-pound Riehle screw-testing machine was used, the specimen plate and bolt being inverted with the bearing plate between it and the head of the machine, the staybolt hanging down through the middle.

The specimens were heated in a small portable forge, alongside the testing machine. The plates, with the bolts projecting upward, were placed on the fire, and the heat localized in the center over a diameter of about 6 inches, by keeping a small, bright fire, and dampening the outside with fine wet coal, to keep it from spreading.

The characteristic failure of the bolts when screwed through and riveted over, was by the sheet bagging down, stretching out the threads to a bell-mouth shape, and shearing off a small annular ring representing the thickness of the riveting. It will be observed, when referring to specimens 1 to 4 and 15, that the edges of the head are very shallow where they are sheared off in line with the edge of the hole, and that the holes are stretched to such an extent that the threads lost their holding power. Generally speaking, the use of a nut increases the holding power of the staybolt over the plain riveting, when tested cold, about 100 per cent. and 50 per cent. when heated to a bright red.

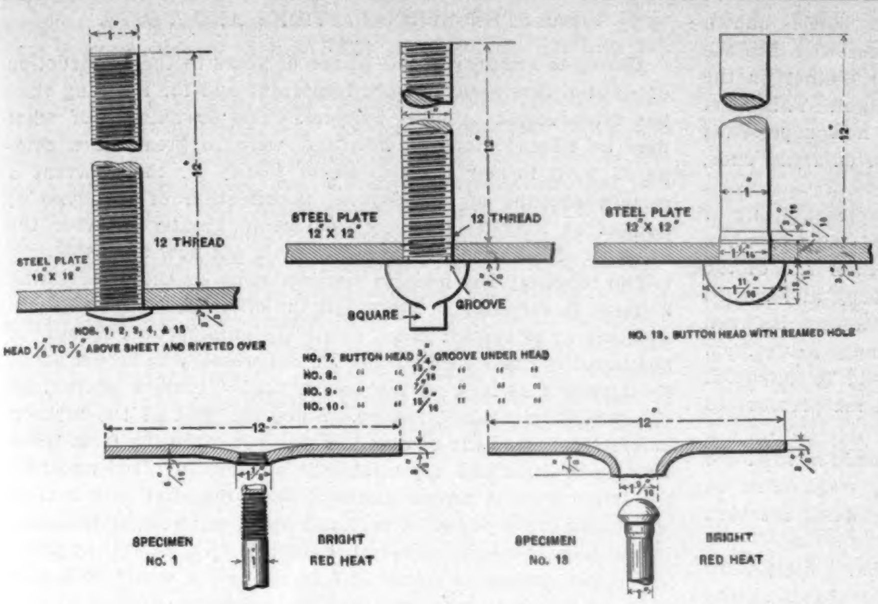
One of the most noticeable features shown in these tests is the comparatively slight decrease in holding power of any of the forms of crown stays until a temperature exceeding a black or dull red has been reached.

*For prevoius article, see Vol. LXXIII., p. 376.



DIA. A	UPSET AT "B" TO
1"	1 5/32"
1 1/8"	1 9/32"
1 1/4"	1 13/32"

Firebox Crown Stays—F. J. Cole.



Diagrams Showing Results of Tests.

the nut will not pull off when overheated until the ultimate strength of the stay is nearly reached. It does not, however, offer so much resistance on the lower end against overheating as a button-head stay with enlarged end, and consequently is not in this respect as good or economical a design.

The sling stay shown in Fig. 4 is used for the first two or three rows. The upper hole is slotted to allow upward movement of the crown sheet to take place. This movement is caused by the expansion of the tube sheet.

The sling stay shown in Fig. 5 represents a neat and simple design with provision for expansion. It consists of only three pieces and allows ample freedom for the upward expansion of the firebox. It is in satisfactory use on the Chesapeake & Ohio and several other roads.

Another form of flexible sling stays for two or three rows in front is illustrated in Fig. 6. This bolt is easily applied and is one in which the adjustment does not depend upon the accuracy of marking off and drilling the pin holes as in Fig. 4. It is used by the Pennsylvania, the Chicago, Burlington & Quincy and other roads.

RECORD OF TESTS.

The average of all the tests, excepting those of lower temperature and of doubtful results, is as follows:

Specimen No.	Tensile Strength.		Remarks.
	Cold.	Hot.	
	Lbs.	Lbs.	
1	16 350	3,470	Head 1/8 inch above sheet, riveted just enough to make steamtight; head not to exceed 1 1/8 inches diameter.
2	16,700	3,473	Head 1/8 inch above sheet, riveted over.
3	17.600	4,040	Head 3/16 inch above sheet, riveted over
4	20,733	4.000	Head 1/4 inch above sheet, riveted over.
5	41,950	....	7/8-inch std. nut, tapped out to 1 inch, 12 threads, and riveted over, projects about 1/16 inch to 1/8 inch.
6	42,000	6.000	1-inch std nut, 12 threads, riveted over; projects about 1/16 inch to 1/8 inch.
7	38,120	7,095	Button head, 3/4 inch groove.
8	39,800	6,933	Button head, 13/16 inch groove.
9	....	7,500	Button head, 7/8 inch groove
10	39,800	7,483	Button head, 15/16 inch groove.
11	39,800	8,766	Button head, no groove, countersunk
12	42,580	9,333	Button head, no groove, 3/16 inch copper washer.
13	43,100	10,150	Button head, with 1 1/16 inch reamed hole.
14	39,720	7.816	1-inch std. nut, 12 threads, nut countersunk [illegible] inch and well riveted over.
15	24,090	4.613	Screwed in sheet, 2 threads, rivet head 3/8 inch high and 1 1/8 inches diameter: largest head which can be formed.
16	40,300	9,730	Button head, with 1 1/4 inches tapered reamed hole, 3 inches thimble and nut.

Sizes of Crown Stays in Actual Use on Different Railroads and the Stresses per Square Inch of net Area.

Type of Boiler.	Dia, of Stay.		Area of Stay at Root of Thread.		Steam Pressure.	Spacing and Area Supported.	Pounds Supported by Each Stay.	Stress per Square Inch.		Remarks.
	Bottom.	Top.	Bottom.	Top.				Bottom.	Top.	
Belpaire..........	1 9/32	1 1/8	1.08	.812	190	4 25x 4.54	3,660	3,390	4,500	
"	1 9/32	1 1/8	1.08	.812	200	4 x 4.21	3,360	3,110	4,120	
"	1 13/32	1 1/4	1.32	1.024	210	4.625 x 4	3,880	2,935	3,830	
Wootten..........	1 9/32	1 1/8	1,08	.812	200	4 x 4 07	3,250	3,010	4,000	
Belpaire......	1 5/32	1	.863	.625	180	4 x 4.06	2,940	3,380	4 700	
Radial stay	1 9/32	1 1/8	1.08	.812	180	4 x 4.31	3,100	2,870	3,820	
"	1 9/32	1 1/8	1.08	.812	200	4.125 x 4.15	3,420	3,170	4,200	
Crown bar.......	1 1/8	1	.99	.55	190	4 x 4	2,880	2,920	5,230	
Radial stay	1 9/32	1 1/8	1.08	.812	180	4 x 4.31	3,100	2,865	3,820	
Belpaire.........	1 5/32	1	.863	.625	180	4.5 x 4.23	3,425	3,968	5 480	
Crown bar.......	1 1/16	1	.89	.55	165	4 5 x 5.25	3,898	4,380	7,087	
"	7/8	7/8	.42	.60	140	4.5 x 5.325	3,386	8,000	5,640	Changed, not in use.
"	1 1/16	7/8	.716	.419	160	4.375 x 4.274	2,992	4,173	7,140	
Radial stay	1	1	.625	625	165	4.375 x 4.3	3,102	4,963	4,963	
"	1 5/32	1	.863	.625	200	4.25 x 4	3,400	3,940	5,440	
"	1 3/16	1	.916	.625	200	4 x 4	3,200	3,490	5,120	
Crown bar........	11/16	7/8	.419	.690	200	4 x 4	3,200	4,637	7,637	
"	1 1/8	1	.99	.55	200	4 x 3 7/8	3,100	3,130	5,636	

The screw crown stay shown in Fig. 3 represents one of the simplest forms in use. When properly riveted over in a countersunk nut it makes a secure stay and one in which

An improper and weak design of crown-bar bolt is shown in Fig. 7. It is inserted through the bar and screwed into the crown sheet from the top. A nut and copper washer on the under side provide means to render it steam tight. This form was used extensively some years ago, but is now superseded by bolts driven up from below (Fig. 8), with enlarged ends, fitted in reamed taper holes.

The form of crown bolt shown in Fig. 8 represents one of the best methods used in the construction of boilers, when the crown sheet is supported by bars. The lower end of the bolt is made about 1/8 inch larger than the body and turned with a taper of 3/4 inch in 12 inches. The washers between the sheet and lower edge of the bars are usually made from 1 1/2 to 3 inches in height. Each crown bar should be supported by two or four sling stays, according to the steam pressure to be carried and the size of the boiler.

Fig. 9 shows an arrangement of crown bars made in the form of rolled tees. In this construction the sling stays must be proportioned to carry the entire load, as the ends of the bars are not supported on the firebox side sheets.

Several years ago a large number of crown-bar boilers were built, for consolidation engines, in which the crown sheets were supported by 7/8-inch diameter bolts, screwed through the sheets and provided with nuts and copper washers in the firebox, the heads of the bolts being on top of the crown bars, arranged as shown in Fig. 7. They were spaced 5 3/8 by 4 1/2 inches, each bolt supporting an area of 24.18 square inches, the steam pressure was 140 pounds. Each bolt therefore sustained $24.18 \times 140 = 3{,}385$ pounds. Diameter at root of threads $10V = 0.731$; area $= 0.42$. Stress per square inch $= 8{,}060$ pounds. When it is observed that the weakest part of these bolts was directly exposed to the fire, and to the chance of overheating—should the water be low—from any temporary cause, the very high stress will be more noticeable.

Area of Crown Bolts at Bottom of Thread (12 per inch) for Diameters from 1 to 1 13/32 Inches and Suggested Working Loads at the Upper and Lower Ends of Same for Radial Stay or Belpaire Boilers.

Diameter.		At Bottom of Thread.		Lower End.	Upper End.
	Decimal.	Diameter.	Area.	3,500 lbs. per sq. in.	5,000 lbs. per sq. in.
1	1.0	.892	.625	2,187	3,125
1 1/32	1.031	.923	.669	2,341	3,345
1 1/16	1.063	.955	.716	2,506	3,580
1 3/32	1.094	.986	.763	2,670	3,815
1 1/8	1.125	1 017	.812	2,842	4,060
1 5/32	1.156	1.048	.863	3,020	4,315
1 3/16	1.187	1.080	.916	3,206	4,580
1 7/32	1.219	1.111	.969	3,391	4,845
1 1/4	1.25	1.142	1.024	3,584	5,120
1 9/32	1.281	1.173	1.080	3,780	5,400
1 5/16	1.312	1.204	1 137	3,980	5,685
1 11/32	1.344	1.236	1 199	4,196	5,995
1 3/8	1.375	1.267	1.261	4,413	6,305
1 13/32	1.406	1.298	1.323	4,630	6.615

These engines were in service for a number of years before any change was made in the crown staying. However, when these boilers were thoroughly repaired, the form of bolt shown in Fig. 8 was applied. This example may be regarded as the maximum stress which, perhaps, could be carried by bolts in connection with crown bars, rather than any form of through staying such as radial or straight Belpaire stays. It may be added that this style of staying and its very high stress, should be viewed as an interesting example of past practice rather than an instance of good design.

The decrease in the construction of crown-bar boilers in the last eight or ten years has been very marked. At the present time over 90 per cent. are built with some form of direct screw stays for the crown sheets. For high pressures of 200 pounds and over there is a distinct advantage in the use of screw stays, from the fact that the safety of the boiler does not depend upon the proper adjustment of the sling stays between the bars and the shell, without which, crown bars for large boilers are insufficient to carry the entire load.

BOLSTER SPECIFICATIONS AND TESTS.

Among the improvements of recent years in the construction of wooden cars none is more important and far reaching than the introduction of steel bolsters. The advantages of what may be termed "modern bolsters" were so great when compared with former practice as to justify at their advent a certain amount of carelessness in selection of the type of bolster as long as the new one would greatly increase the capacity of the cars. This, however, is not now advisable.

The tendency has been to consider price as the determining element in selecting bolsters, but the differences in design are so great as to render this a relatively unimportant factor. It has in many cases been considered unnecessary to bother about the strength as long as the bolster manufacturers guaranteed the purchaser against failure. Since the first of the modern bolsters appeared the subject has received attention from those who understand and appreciate the stresses involved and also the importance of proper distribution of material with a view of making every pound of material count in terms of strength. It is evidently now necessary to take this fact, as well as price, into consideration in selecting bolsters and it would be better business policy to buy on a basis of strength, durability and price.

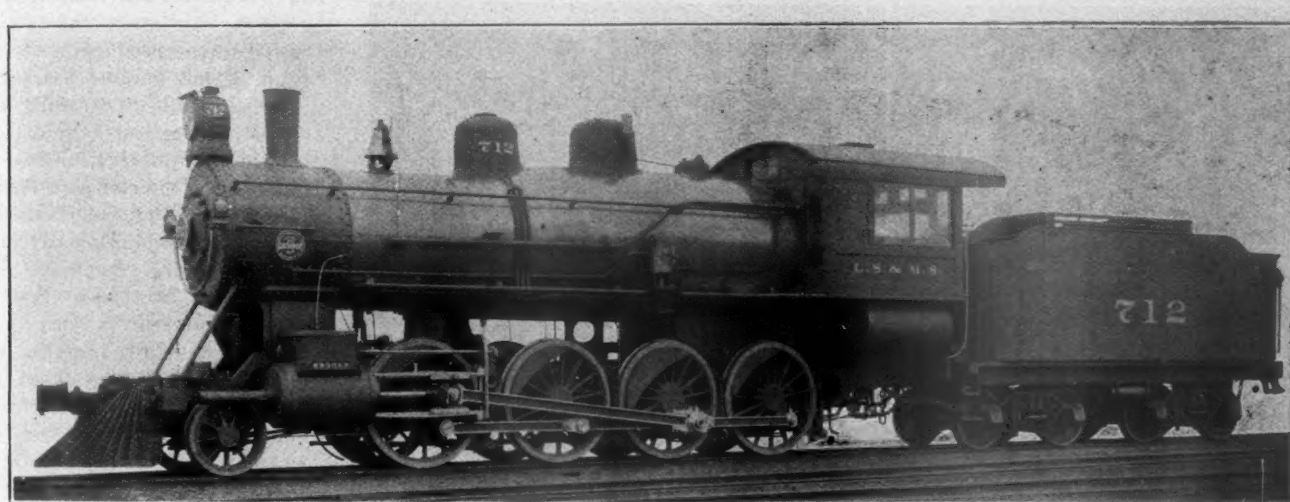
Admitting that several designs of bolsters may be depended upon to give good service, why not include in the specifications the limiting stresses per square inch in the tension and compression members and ask for bids on this basis? The design which keeps within the limits of the required stresses and has the minimum total weight could then be selected. These considerations coupled with the advantages in simplicity, durability, ability to go through wrecks without injury and price, would give the necessary information for intelligent comparison and all the bolster makers would be put upon the same basis. The question of the best distribution of metal could be answered and those bolsters which are systematically designed to carry the cars free from the side bearings would stand out prominently. This feature of bolsters does not appear to have been fully appreciated, and it is evident that if a bolster is designed with a view of separating the side bearings it must be very much heavier and consequently much more expensive to construct than one in which this feature is not provided.

The question of strength and allowable fiber stress in bolsters is an important one because of its bearing upon the weight of the structures, which must be hauled in trains. The stress should be as high as practicable because the higher it is the less material is required to make the bolsters, and yet the limit of safe strength for indefinite service must not be passed. The elaborate report on the design of axles before the Master Car Builders' Association in 1896 provides for 98.4 per cent. of the static load (in addition to the static load) as the maximum result of vertical and horizontal oscillations. This means that for an axle, double the static load should be provided for, but bolsters are not subjected to the rapidly alternating stresses of the axle and bolsters are also cushioned by the springs, which facts should be considered as effectively reducing the proportion of load due to shocks to perhaps 50 per cent. of the quiet load. This figure is merely estimated, but it serves to show that the subject of the strength of bolsters requires study in order to obtain all of the advantages offered by the use of metal in their construction.

A feature of bolster design about which very little is heard is transverse strength. This is exceedingly important in connection with the stopping of fully loaded cars of large capacity and that the stresses in this direction are great is not questioned. In fact, we believe that most of the bolsters which have failed have failed transversely. We are told that modern bolsters which have developed this weakness show a transverse strength of only from one-third to one-fifth of that of old wooden bolsters. There is plenty of room in the car structure to provide for these stresses, and the limit of transverse strength is that determined by the weight of the bolster.

From a brief consideration of these factors it seems clear that a great deal of thought may be profitably put into the design of bolsters.

Drop tests have been suggested and are now seriously considered as offering means for comparing bolsters. With this method it is possible to submit different specimens to the same conditions of test, but the objection raised is that this is not a service test under working conditions, and that a loading test from which fibre stresses could be ascertained would be a fairer method, which would give the kind of information desired. No one would consider submitting a draw span of a bridge to an impact test. It would be advantageous to submit a bolster to a heavy static load and then note the effect of a sudden increase of load of perhaps 50 or 60 per cent. of the static load, but if this cannot be done the method of gradually applied load and measurement of deflection seems to offer the best study of a bolster.



Consolidation Locomotive—Lake Shore & Michigan Southern Railway.

W. H. MARSHALL, *Superintendent Motive Power.* BROOKS LOCOMOTIVE WORKS, *Builders.*

CONSOLIDATION FREIGHT LOCOMOTIVES.

Lake Shore & Michigan Southern Railway.

One of 25 consolidation freight locomotives just completed by the Brooks Locomotive Works for the Lake Shore & Michigan Southern is illustrated by the accompanying engraving.

These locomotives are much more powerful than any previously built for this road, but they do not approach the weight and power of some of the designs for other roads which are not as favorably situated as to grades as the Lake Shore. They will haul as long trains as it is desirable to handle on this road, where extremely heavy freight locomotives are not needed. The cylinders are 21 by 30 inches, the driving wheels are 62 inches in diameter, and the weight on drivers is 149,000 pounds. At 85 per cent. of boiler pressure in the cylinders the tractive power is 36,000 pounds. The boiler is of the extended wagon top type, with the firebox above the frames. The heating surface is 2,686 square feet and the grate area 33.5 square feet.

The most interesting feature of the design is the care given to the details with the object of reducing the number of breakdowns on the road. The piston rods have enlarged ends, the axles throughout, including the truck axles, and the crank pins, have enlarged wheel fits, and the journals are large for an engine of this weight. All of the driving wheels are of cast steel. The driving wheel brakes are arranged in accordance with the plan illustrated on page 46 of this issue, the advantages of which are stated in connection with the description of the brake rigging of the fast passenger locomotives by the Brooks works for the same road. The following table summarizes the chief dimensions and particulars of the design:

Consolidation Freight Locomotive, L. S. & M. S. Railway.

Kind of fuel to be used	Bituminous coal
Weight on drivers	149,000 lbs.
Weight on trucks	19,000 lbs.
Weight, total	168,000 lbs.
Weight, tender, loaded	118,000 lbs.
Wheel base, total, of engine	25 ft. 6 in.
Wheel base, driving	17 ft. 4 in.
Wheel base, total, engine and tender	55 ft. 4¼ in.
Length over all, engine	41 ft. 5½ in.
Length over all, total, engine and tender	65 ft. 3 in.
Height, center of boiler above rails	9 ft. 2 in.
Height of stack above rails	14 ft. 10 in.
Heating surface, firebox and arch tubes	230 sq. ft.
Heating surface, tubes	2,452 sq. ft.
Heating surface, total	2,682 sq. ft.
Grate area	33.5 sq. ft.
Drivers, diameter	62 in.
Drivers, material of centers	Cast steel
Truck wheels, diameter	36 in.
Journals, driving axle, main	9½ in. by 12 in.
Journals, driving axle, main wheel fit	9¾ in.
Journals, driving axle, others	8½ in. by 12 in.
Journals, driving axle, others, wheel fit	9 in.
Journals, truck axle	6 in. by 12 in.
Journals, truck axle, wheel fit	6½ in.
Main crank pin, size	6½ in. by 6½ in.
Main coupling pin, size	7¼ in. by 4½ in.
Main pin, diameter wheel fit	7⅝ in.
Cylinders, diameter	21 in.
Piston, stroke	30 in.
Piston rod, diameter	3¾ in.
Main rod, length center to center	142½ in.
Steam ports, length	19 in.
Steam ports, width	1⅝ in.
Exhaust ports, length	19 in.
Exhaust ports, width	2¾ in.
Bridge, width	1⅝ in.
Valves, kind of	Allen, Richardson
Valves, greatest travel	5¾ in.
Valves, outside lap	1 in.
Valves, inside lap	None
Lead in full gear, forward	3/32 negative
Boiler, type of	Brooks improved extended wagon top
Boiler, working steam pressure	200 lbs.
Boiler, thickness of material in shell	⅝ in., 11/16 in., ¾ in., 9/16 in. ½ in.
Boiler, thickness of tube sheet	¾ in.
Boiler, diameter of barrel, front	64½ in.
Boiler, diameter of barrel at throat	76 in.
Boiler, diameter at back head	66 in.
Seams, kind of horizontal	Sextuple butt
Seams, kind of circumferential	Double and triple
Crown sheet, stayed with	Radial stays, with button heads
Dome diameter, inside	30 in.
Firebox, type	Over frames
Firebox, length	121 in.
Firebox, width	41 in.
Firebox, depth, front	80 in.
Firebox, depth, back	67 in.
Firebox, thickness of sheets	Tube, ⅝ in.; sides, back and top, ⅜ in.
Firebox, brick arch	On water tubes
Firebox, mud ring, width	Back, 3½ in.; sides, 4 in.; front, 4½ in.
Firebox, water space at top	Sides, 5 in.; front and back, 4½ in.
Grates, kind of	Cast-iron rocking
Tubes, number of	312
Tubes, material	Charcoal iron
Tubes, outside diameter	2 in.
Tubes, thickness	No. 11 B. W. G.
Tubes, length over tube sheets	15 ft. ¼ in.
Smoke box, diameter outside	67 in.
Smoke box, length from flue sheet	65 in.
Exhaust nozzle	Single
Exhaust nozzle, diameter	4⅞ in., 5 in., 5⅛ in.
Exhaust nozzle, distance of tip below center of boiler	2½ in.

Netting, wire or plate .... Plate
Netting, size of mesh or perforation .... 3/16 by 1½ by ⅜ centers
Stack, straight or taper .... Steel, taper
Stack, least diameter .... 15 in.
Stack, greatest diameter .... 16⅞ in.
Stack, height above smoke box .... 34½ in.

Tender.

Type	Eight-wheel, steel frame
Tank, type	"U" shape, with gravity slides
Tank, capacity for water	6,000 gal.
Tank, capacity for coal	12 tons
Type of under frame	Brooks 10-in. steel channel
Type of truck	Brooks 100,000 lbs.
Type of springs	Triplicate elliptic
Diameter of wheels	36 in.
Diameter and length of journals	5½ in. by 10 in.
Distance between centers of journals	5 ft. 6 in.
Diameter of wheel fit on axle	6⅞ in.
Diameter of center of axle	5⅞ in.
Length of tender over bumper beams	21 ft. 10½ in.
Length of tank, inside	20 ft. 4 in.
Width of tank, inside	9 ft. 10 in.
Height of tank, not including collar	5 ft. 0 in.
Type of draw gear	Brooks M. C. B. freight

Tender fitted with water scoop.

SOME CAUSES OF EXCESSIVE HEATING IN BEARING METALS.

Importance of the Microscope.

By Robert Job.

Chemist, Philadelphia & Reading Railway.

It is a fact well known to those who have made a study of bearing metals that physical condition and structure exert a marked influence upon the efficiency of the metal in service. Formerly great stress was laid upon the chemical composition of the alloy, and comparatively little attention was paid to the effects of the different conditions of foundry practice, or to the relation between structure and efficiency. The natural results followed, and "hot-boxes" became prevalent in railway practice, especially so when weights and speeds became materially increased. Attention was thus directed to the production of cool-running and durable bearings.

As a result of carefully conducted service tests, the old copper-tin alloy of seven to one was found to be inferior as a bearing metal, and the copper-tin-lead composition was gradually introduced, at first combined with phosphorus, and later with this element present in very small amount, if at all, and then used only as a deoxidizing agent. The efficiency of a copper-tin-lead composition, other things being equal, was shown by Dr. Dudley to increase with the proportion of lead which was present, the amount being limited owing to inability to combine more than about fifteen per cent. with copper to form a homogeneous composition. A large excess of lead was also avoided owing to the necessity of maintaining a strength sufficient to support the load, and also a fairly high melting point in order to prevent fusion and running from the box if heating resulted.

During the past few years greatly increased attention has been paid to the microscopic study of the metals, and the importance of this method of investigation is becoming clearly recognized in view of the results which are being obtained through its use. In the course of an investigation to determine the alloy most efficient for general railroad use, we found it desirable to follow up this structure of bearing metals in order to note the influence of this as well as that of the chemical composition upon durability in service.

In order to secure information, a large number of bearings which had run hot and had been removed from cars of different railroads while passing over the Philadelphia & Reading Rail-

Fig. 1.

Fig. 2.

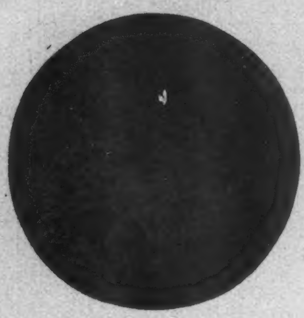


Fig. 3.

Fig. 4.

Fig. 5.

Fig. 6.

Fig. 7.

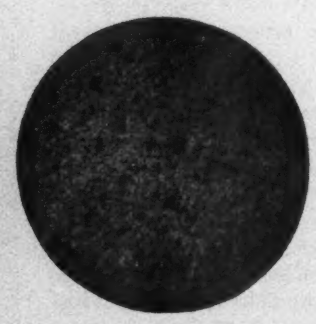


Fig. 8.

Fig. 9.

Fig. 10.

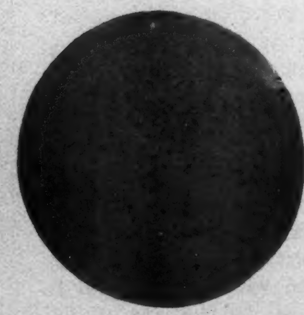


Fig. 11.

way were taken for test. Fractures were made to show the general physical character of the composition, sections for microscopic examination were removed, polished, etched, magnified as far as necessary to show the structure to best advantage, and photographed. Analyses were also carried on at the same time, especially in cases where marked segregation of the metal was found to exist, in order to determine whether this result was due simply to an attempt at the foundry to form an alloy in proportions which were physically impracticable, or whether it was merely an effect of improper foundry manipulation. The marked crystallization which was often found in these bearings was also investigated in a similar manner. Also, in the majority of cases test sections were cut from the bearings, and the tensile strength and elongation determined, in order to find out whether in a given composition proper foundry practice would not be insured by placing a minimum limit upon the strength and ductility of the alloy.

Side by side with these tests a considerable number of alloys have been prepared in the foundry to check the accuracy of the deductions, and to secure information as to the conditions of foundry practice necessary to give the greatest strength and ductility to the given composition.

By means of this study it has been possible to determine the causes of excessive heating in the large majority of the bearings examined, and we may summarize them as follows:

First, Segregation of the metals.

Second, Coarse crystalline structure.

Third, Dross or oxidation products, and an excessive amount of enclosed gas in the metal.

In addition to these, the lack of proper lubrication might be mentioned, though our investigation seems to show that a relatively small percentage of the bearings examined had been discarded owing solely to this cause.

Segregation has been found to be due in many cases to an attempt to alloy the metals in improper proportions, this being notably the case in some of the copper-tin-lead compositions in which an excessive proportion of lead had been introduced, resulting in the liquation not merely of a portion of the lead, but often also that of a part of the copper into "copper-spots," thereby producing surfaces of relatively high heating capacity, and ultimately causing "hot-boxes." Figure 3 represents a photomicrograph of a copper-tin-lead composition which had segregated owing to pouring too rapidly when at too high a temperature. In this case a portion of the lead had separated out, and also a slight crystallization is seen owing to the presence of a slight excess of silicon in the metal. Figure 1 is a photograph showing upon one side the fracture of a badly segregated bearing with "copper spots," and upon the other that of a well-mixed and homogeneous composition—the segregation in the one case being due partly to the presence of an excessive amount of lead in the brass, and partly to improper foundry practice.

To a certain extent, these segregations may be prevented in a wrongly proportioned composition simply by a rapid chilling of the metal immediately after pouring, as for instance by the use of a cold iron mould. Such practice, however, is at the expense of the ductility of the metal, and causes a marked increase in brittleness with consequent rapid wear in service. High heating combined with rapid pouring and feeding is also a frequent cause of segregation, since under such conditions the metal in the mould remains for a considerable time in a molten condition, and by chilling gradually is given the greatest possible chance to solidify in definite natural alloys, throwing out whatever excess of metal may be present beyond these proportions, and thus resulting in segregation.

In actual service the effect of these segregations is readily understood, for it is evident that instead of an alloy of uniform hardness and heating capacity, there is a mixture, some portions of which are relatively very hard and others very soft, and this difference combined with that occasioned by the varying heating capacity of the different portions naturally localizes friction, and ultimately results in excessive heating. In a homogeneous alloy or composition no such conditions exist, and although, as is true of some compositions, some of the metals may be present, at least in part, in mere mechanical mixture and not as a definite alloy, yet the particles may be made so small by proper foundry practice that the friction throughout the bearing is practically uniform, and undue local heating is not liable to occur excepting through some outside agency.

The coarsely crystalline structure which was often seen in these defective bearings was in some cases found to be due to the composition of the alloy, antimony especially tending in this direction. In many cases, however, it has been traced to the foundry practice, often being due to rapid pouring at high temperature. Crystallization was also caused in some cases by the presence of an excess of various materials which were originally added as deoxidizing agents. Phosphorus and silicon are good examples. These, if added in suitable proportions, depending upon the condition of the metals, effect cleansing and free the metal from a large proportion of its enclosed gas, adding greatly to the fluidity, and thus rendering the casting less porous, and at the same time increasing strength and ductility often to a marked extent, correspondingly increasing the capacity for wear. Excess of these materials beyond the amount required for deoxidation appears not to be thrown off from the metal in the form of oxides very appreciably, but causes a crystallization which in a number of the bearings examined was so marked that it not only occasioned serious weakness and lack of ductility, but also such an increase in frictional qualities that cool running under the ordinary conditions of service was evidently an impossibility since the brasses had run hot and had been discarded from service shortly after the lead lining had been worn away. Figures 4 and 5 represent photomicrographs of two of these metals, and the structures show clearly the source of the heating.

One great advantage in the use of the microscope in connection with the deoxidation of these compositions lies in the fact that it becomes possible to tell quickly and with certainty the exact amount of the deoxidizer which is needed to combine with the oxygen present, without leaving more than a trace of the material behind in the finished casting to act as a weakener.

The effects of this coarse crystallization upon the durability of the bearing are two-fold. In the first place, increased local heating results in the same manner as in the case of segregated bearings, owing to the varying degrees of hardness and heating capacity of the constituents, and secondly, the ductility of the metal and the tensile strength are materially decreased. As the rapidity of wear with a given strength has been proved repeatedly by different experimenters to increase with the brittleness, it thus becomes evident that the durability of one of these crystallized bearings in service is bound to be defective owing to an excessive rate of wear, even though the heating which would naturally result should not occur.

Figure 10 represents a segregated copper-tin alloy containing about eighty per cent. of copper and about 0.1 per cent. of phosphorus, showing the crystalline structure of such composition, and it may be mentioned in passing that the old copper-tin alloy of seven to one, having a somewhat similar structure, and formerly much used for bearing metal, is a notoriously rapidly heating composition, and is not often found to-day in railway practice. Figure 2 is a photograph of the fracture of one of these badly crystallized brasses together with one showing a homogeneous and fine-grained structure.

Another very common source of difficulty found in defective bearings was the presence of particles of dross or oxidized metal mechanically enclosed, and also of large amounts of occluded gas in the metal. In the former case a hard cutting surface was presented to the journal, causing increased friction and hence heating. The presence of occluded gas in excess also tended in the same direction by reducing the actual bearing surface of the brass, and thus materially increasing the

pressure. Such metal was naturally found to be very brittle, and to have worn rapidly in service. In the foundry practice, the presence of this enclosed matter is as injurious as in the bearings themselves, tending to cause sluggish pouring, unless the metal is heated to a very high temperature, in which case crystallization and segregation—as shown above—are liable to result unless the speed of pouring is very carefully regulated.

Figures 6 and 7 represent dross mechanically enclosed in a copper-tin-lead composition, and Figures 8 and 9 show the appearance of the metal when containing an excess of occluded gas, and show clearly the loss of bearing surface which may result from such porous condition.

The presence of dross enclosed in a bearing is simply a proof of carelessness in the foundry and is due either to defective skimming or to pouring from the bottom of the pot. In either case proper oversight will prevent the difficulty. An excess of enclosed gas, on the other hand, is ordinarily due to lack of proper deoxidation of the metals, though at times it is also caused by pouring at too low a temperature. Thus it indicates not necessarily carelessness, but rather a lack of knowledge upon the part of the foundryman, of efficient foundry methods.

Figure 11 represents the structure of a copper-tin-lead composition, close-grained and homogeneous, showing only a slight crystallization, the brass having been deoxidized with a slight excess of phosphorus.

Turning now to the influence of the above-mentioned defects upon the tensile strength and elongation of the bearings examined, in every instance we have found the result which would be expected. The presence of dross or any foreign matter in the metal introduces an element of weakness, and thus reduces both the tensile strength and the elongation. Coarse crystallization produces the same result, the faces of the crystals forming the surface of least resistance, and thus facilitating fracture, and diminishing ductility. A test section taken from the bearing represented by Figure 5 showed a tensile strength of only 10,500 pounds per square inch with an elongation of only four per cent. in a 2-inch section. A bearing of the same composition if properly prepared in the foundry and free from crystallization would have a tensile strength of about 25,000 pounds per square inch and an elongation of about 13 per cent. when the test sections were taken from the bearing in a similar manner.

In the porous brasses we naturally found the same lack of strength and ductility owing to the deficiency in the amount of the metal present in a given section. For example, the bearing represented by Figure 8 showed a tensile strength of 15,000 pounds per square inch with an elongation of only six per cent. Figure 9 showed a tensile strength of 18,700 pounds per square inch, with seven per cent. elongation. Thus, we see that the influence of the various defects is clearly shown when metal of a known composition is subjected to the tensile tests, and it becomes possible to hold the foundry up to a high grade of excellence by means of these comparatively simple tests, with analytical and microscopic work as a basis.

Objection may perhaps be made that it appears rather arbitrary to place limits upon tensile strength and elongation in bearings, and that after all in practical service it is merely necessary to have, with a proper composition, a fairly strong homogeneous material, to obtain good results. In reply we will merely state that as a result of very carefully conducted service tests made by placing bearings of practically the same composition but differing widely in both tensile strength and elongation upon opposite ends of the same axles, we have invariably found that an increase of strength and ductility meant an increased life to the bearing in service and a lessening of wear, our results in this respect being in accordance with the deductions given by Dr. Dudley in 1892 before the Franklin Institute. As an instance of difference in efficiency due to these causes, we may cite a service test in which eight bearings each, of two copper-tin-lead compositions, were placed under tenders of fast passenger locomotives, one bearing of each kind being placed upon an end of each axle. All of the bearings were of practically the same composition, but the one set showed a tensile strength of about 16,500 pounds per square inch with an elongation of about six per cent., while the other had a strength of about 24,000 pounds per square inch with an elongation of about 13 per cent. This marked difference was due simply to the fact that in the one case the metal was porous, about as shown in Figure 8, while the other was thoroughly deoxidized, and was close grained and homogeneous, somewhat similar in structure to Figure 11. From time to time these bearings were removed and weighed, and the end-wear measured. As a final average result it was found that the more brittle set had worn thirty-five per cent. more rapidly than the other set. The results of similar tests also have been in line with these results. Therefore it becomes evident that increased ductility and strength in the bearing of given composition means, as stated, an increased life for the bearings in service, and as this increased ductility necessitates also freedom from the defects which we have mentioned above, it is evident that the chances of cool-running are proportionately increased. These qualities are therefore not merely of theoretical interest, but have also an intensely practical value, and have a marked influence upon the success and economy of railway service.

Regarding the preparation of the sections for microscopic study, we have found it desirable to cut them from the center of the bearing, filing and polishing after the usual methods, and finally etching with an approximately deci-normal solution of iodin in potassium iodide—the time of etching being usually about one minute. This etching gives very satisfactory results in many cases, although in some cases etching with dilute nitric or with dilute chromic acid has shown the structure to better advantage. In this much depends upon the information desired. In ordinary work we have found that magnification to about thirty diameters is sufficient to show the general structure to good advantage.

In connection with our work it is clearly indicated that too much stress can hardly be laid upon the importance of the microscopic study of these alloys owing to the definite knowledge which is given regarding not only the composition of the alloy, but the general physical structure, the presence or absence of friction producing agencies, and owing also to the check which is given over routine foundry practice.

GRATES FOR COKE BURNING.

In pursuing the subject of coke burning on locomotives to supplement the facts taken from the Boston & Maine practice (October issue), the most satisfactory information comes from Mr. J. S. Turner, Superintendent of Motive Power of the Fitchburg Railroad, who has been quietly working on this line for some months, and now uses coke in regular service without mixing it with soft coal, without using a steam jet under the grates and by making no changes except to get up a new cast-iron grate with a rather unusually large proportion of air openings. With this grate he has no difficulty in using all the coke that he can get, and whenever the coke supply gives out he uses coal on the same grates with equal facility. The increased air space appears to be beneficial also with coal.

The engraving of Mr. Turner's new grate shows no novel features. It is a box pattern which many will know as the Reagan pattern, although it is not the Reagan grate. The old finger grate is illustrated also, for convenient comparison. This grate will burn coke, but there was insufficient air space for good steaming. The grates have been very carefully calculated and the comparison is given here in full because of the general interest in the subject.

The comparison is based upon a 66 by 35-inch firebox on the Fitchburg locomotive No. 42, with a total area of 2,310 square inches. The areas in detail are as follows:

THE NEW BOX GRATE.

Total area of one grate	238.13 sq. in.
Open area	102.18 sq. in.
Closed area	135.95 sq. in.
Number of grates used	8.
Covered area of 8 grates	1,087.56 sq. in.
Covered area of side bars	198.00 sq. in.
Total covered area	1,285.56 sq. in.
Total open area	1,024.44 sq. in.

THE FINGER GRATE.

Number of end grates	2.
Number of intermediate grates	5
End bars, 2 in number	2½ in.
End bars, 2 in number	1¾ in.
Area of end bars	175.00 sq. in.
Area of side bars	231.00 sq. in.
Total area of end grates	310.00 sq. in.
Open area of end grates	151.24 sq. in.
Covered area of end grates	317.52 sq. in.
Total area intermediate grate	372.00 sq. in.
Open area intermediate grate	213.24 sq. in.
Total covered area intermediate grates	793.80 sq. in.
Total covered area in firebox	1,517.32 sq. in.
Total open area in firebox	792.68 sq. in.

COMPARISON.

	Box Grate.	Finger Grate.
Total area	2,310.00 sq. in.	2,310.00 sq. in.
Covered area	1,285.56 sq. in.	1,517.32 sq. in.
Open area	1,024.44 sq. in.	792.68 sq. in.
Per cent. open	44.35	34.32
Per cent covered	55.65	65.38

This exhibits an advantage of 10 per cent. of open area in favor of the box grate, the construction and support of which appears to be more favorable than that of the finger type. The open area is even then not nearly up to the practice in other branches of engineering, and it is perhaps possible to exceed these figures without reaching the practical limit. This example raises the question of the most advantageous proportions of air openings, which is a subject which is worth considerable study, but only on a stationary testing plant can figures be obtained that would be of value in guiding design.

Mr. Turner does not find it necessary to use water grates, and, as previously stated, they are not now fitted to Boston & Maine engines for this fuel. It should be stated here that the water grate illustrated in our October issue was an adaptation of a form the patent for which is held by the Hancock Inspirator Co.

Coke burning on the Baltimore & Ohio was taken up on account of the smoke problem, and it has been used with entire satisfaction for a number of years on that road, but the expense is greater than with coal. The grate arrangement is shown in the engraving.

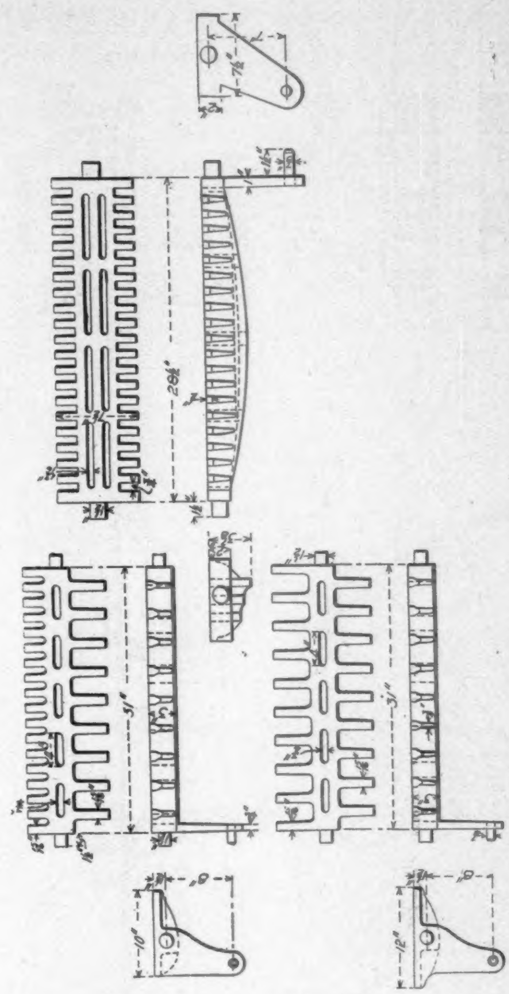
The coke used is the 24-hour lump coke from the Cumberland and Pittsburgh districts. At first considerable trouble was experienced from the formation of clinkers on the tube sheet, which gradually spread until the tube ends were nearly closed. A remedy was found in the use of bituminous coal mixed with the coke in the following proportions:

Length of run.	Coal.	Coke.
25 miles	8 per cent.	92 per cent.
50 miles	10 per cent.	90 per cent.
75 miles	12½ per cent.	87½ per cent.
100 miles	15 per cent.	85 per cent.
125 miles	17½ per cent.	82½ per cent.
150 miles	20 per cent.	80 per cent.
175 miles	22½ per cent.	73½ per cent.
200 miles	25 per cent.	75 per cent.

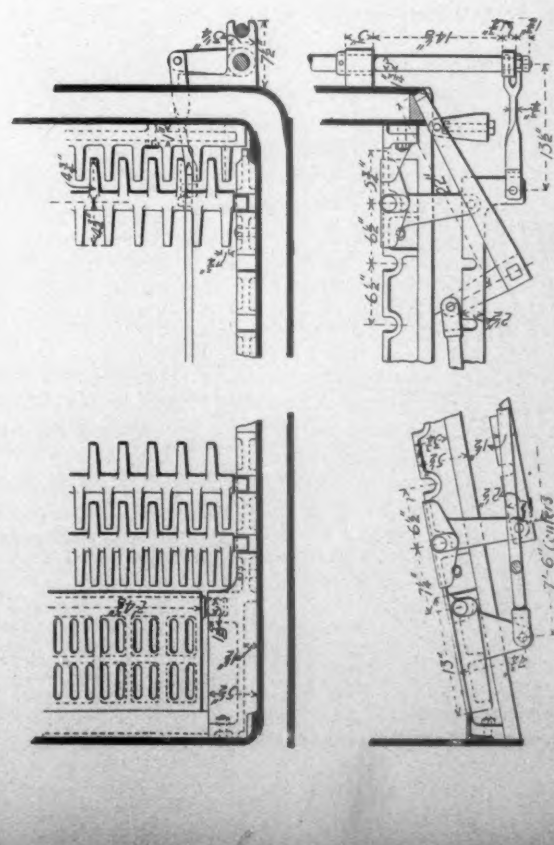
On this road it is customary to start the fires with coal, because coke does not kindle readily. After the coal fire has thoroughly ignited, the coke is introduced and a heavy fire is usually carried because the coke does not pack closely and cold air is passed up through the fire, which reduces the firebox temperature. A heavy fire prevents this.

It has sometimes been found advantageous to locate four or five air holes in the sides of the fireboxes, about 15 inches above the grates, in case the length of the firebox is greater than 10 feet. The brick arch is not used in coke burning engines on the B. & O. It interferes with getting the proper depth of fire. As a result of an extended experience, it has been found that coke is more injurious to steel fireboxes than was the case with coal.

While on the subject of grates for coke burning, it may be interesting to know that on the Alley Elevated, in Chicago, the engines at first burned coke exclusively, and for several months a number of engines were kept at work for 24 hours a day. They were of the ordinary finger type and of cast-iron. A hard coating formed on the tube sheet, but it was easily brushed off, and it was not serious enough to necessitate the admixture of soft coal.



Box and Finger Grates, Fitchburg R. R.



Grates Used with Coke Baltimore & Ohio R. R.

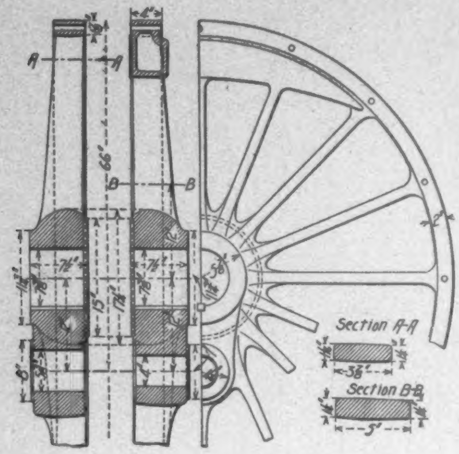


Fig. 1.

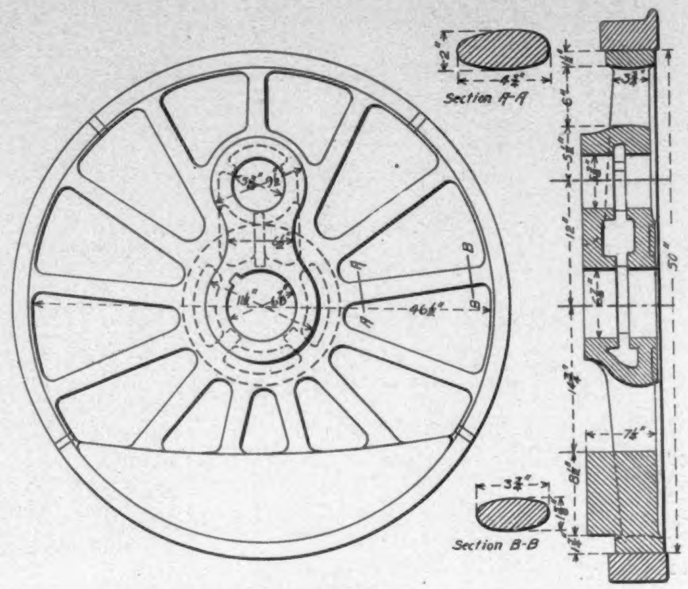


Fig. 2.

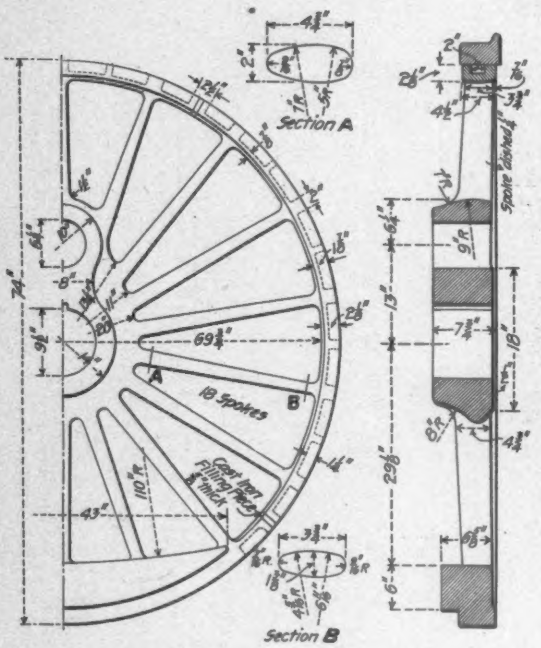


Fig. 3.—Fast Passenger, C. & N. W. Ry.

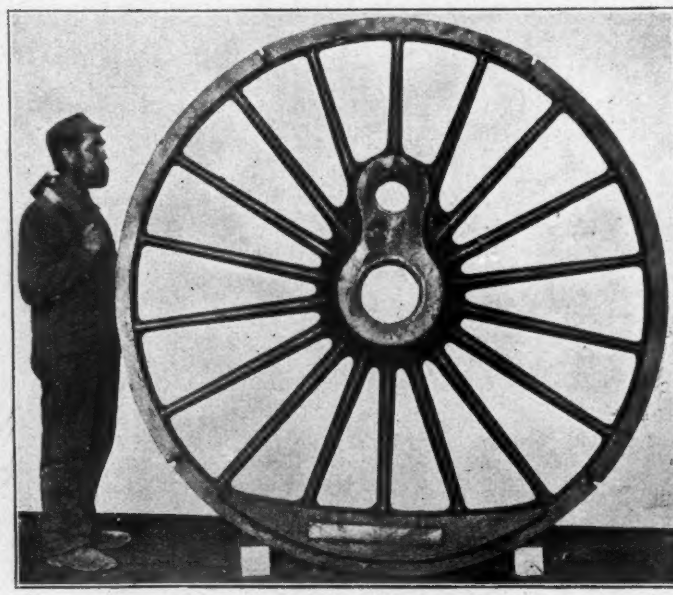


Fig. 4.—Same as Fig. 3.

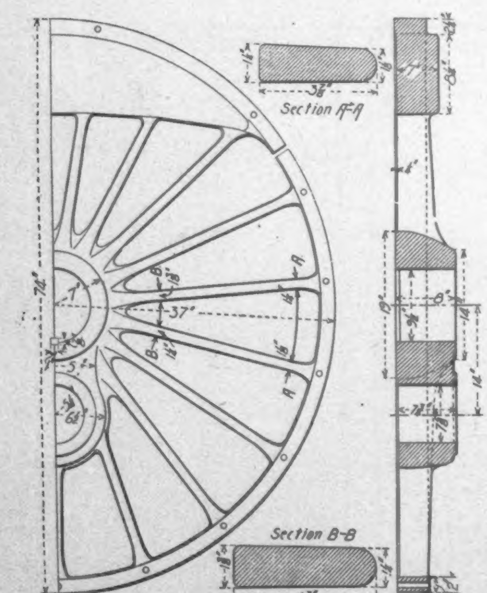


Fig. 5.—Lake Shore Passenger, Main Wheel.

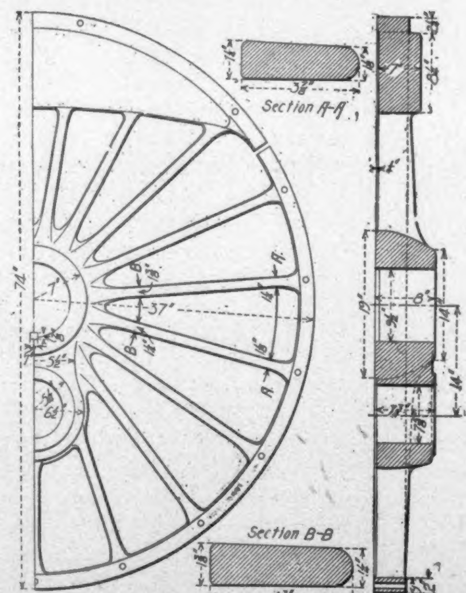


Fig. 6.—Lake Shore Passenger Front and Rear Wheels.

CAST STEEL DRIVING WHEELS.

This collection of information concerning various designs of locomotive driving wheels resulted from a consultation with a motive power officer who sought information with reference to the lightest structures which it is advisable to use for both passenger and freight service. An inquiry developed differences of opinion as shown by the drawings, and it was discovered that some people have actually ordered cast steel wheels made from patterns which had previously been used for cast iron wheels. Comment on this practice is unnecessary. There is no locomotive detail in which so much weight is to be saved by the use of cast steel as in driving wheels. It is specially important to save the weight of these parts because they are not cushioned by the springs and are more destructive to the track than the parts which are carried above the springs. The possibilities of light construction selected from successful and accepted practice are indicated in these examples.

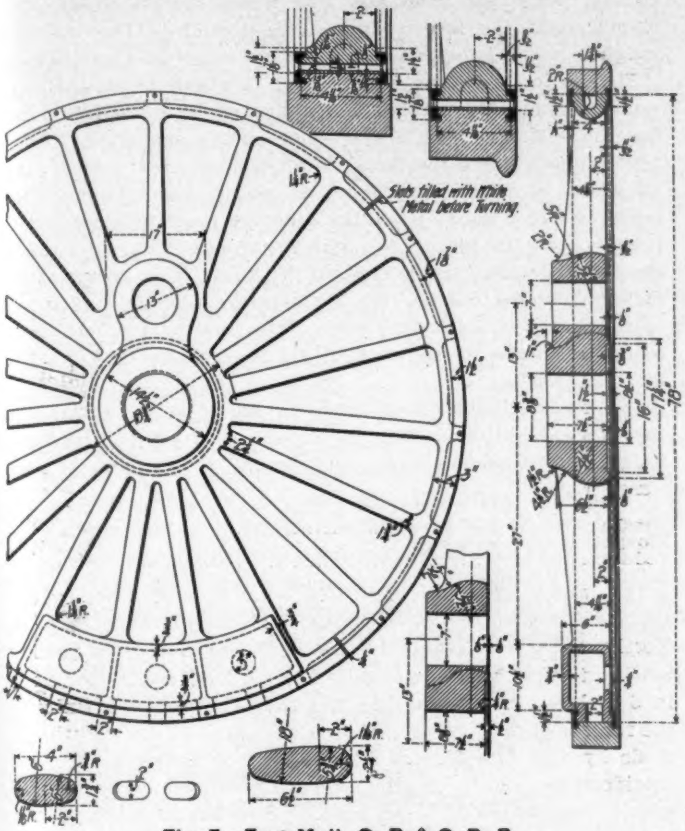


Fig. 7.—Fast Mail, C. B. & Q. R. R.

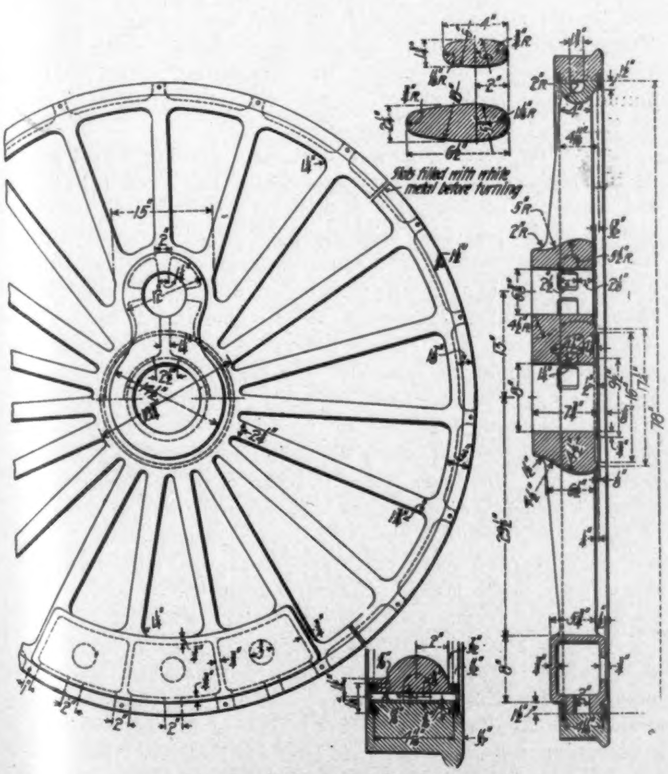


Fig. 8.—French State Railway.

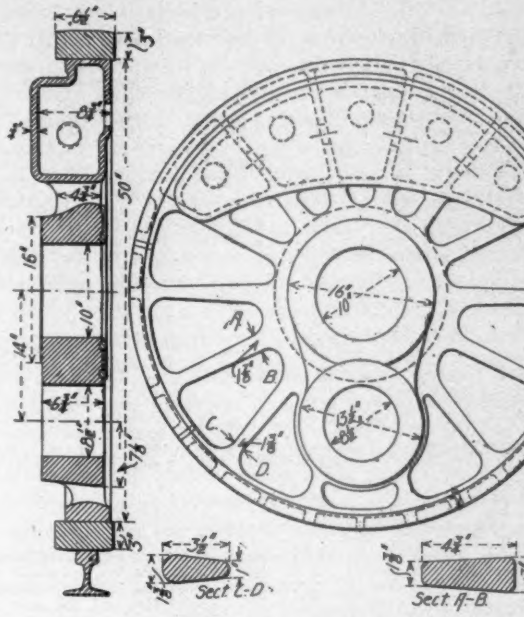


Fig. 9.—Recent Heavy Consolidation.

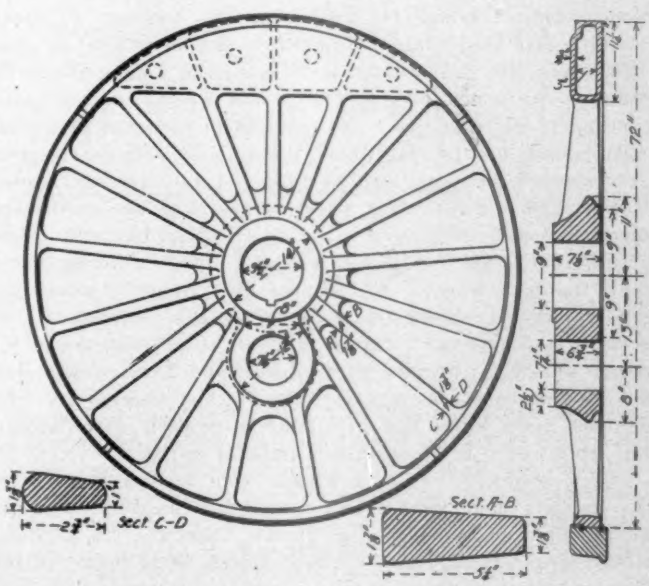


Fig. 10.—Atlantic Type Fast Passenger.

The design of a 66-inch wheel, shown in Fig. 1, which was made about 4 years ago, effected a saving of nearly 21 per cent. over the weight of cast iron wheels of the same size. The comparison is as follows:

2 66-inch centers.	Cast Iron. Lbs.	Cast Steel. Fig. 1. Lbs.
Front	5,080	3,156
Back	4,780	3,124
Add lead for counter balance	.....	1,520
Total	9,860	7,800
Saving in weight		20.9 per cent.

These cast iron wheels had the counterweights cast solid.

In freight wheels with smaller diameters, the advantage is less if the counterweights are of lead. The following table gives comparisons of 56-inch wheels, representing 10-wheel engines with the counterbalance weights cast solid, and another design with lead balance weights. In the case of the lead weights the advantage is less than 1 per cent., but these cast steel wheels are probably much heavier than safety requires.

Wheel Centers With Counterweights Cast In.

	Cast iron.	Cast steel.	Saving in Weight %
Two 56-inch centers, front.........	3,300 lbs.	2,640 lbs.	
Two 56-inch centers, main.........	3,700 lbs.	3,097 lbs.	
Two 56-inch centers, back.........	3,300 lbs.	2,783 lbs.	
Total weight....................	10,300 lbs.	8,520 lbs.	17.28%

Wheel Centers with Lead Counterweights.

	Cast iron.	Cast steel.	Saving in Weight %
Two 56-inch centers, front.........	3,260 lbs.	2,773 lbs.	
Two 56-inch centers, main.........	3,568 lbs.	2,956 lbs.	
Two 56-inch centers, back.........	3,260 lbs.	2,798 lbs.	
Total weight....................	10,088 lbs.	8,527 lbs.	
Add lead for balance weights.....		1,475 lbs	
Total weight....................		10,002 lbs.	.00852%

A 50-inch freight wheel is shown in Fig. 2. This is the last wheel in the list of seven given in the table below, and it represents a saving of 28 per cent. The section of the spokes is elliptical in this case. This design also was made about four years ago.

Finished Weights of Driving Wheel Centers.

Size.	Cast steel.	Cast iron.	Difference.	Saving.
36-inch.............	1,834 lbs.	2,360 lbs.	526 lbs.	22.3 per cent.
32-inch.............	1,646 lbs.	2,139 lbs.	493 lbs.	23.1 per cent.
32-inch.............	1,637 lbs.	2,150 lbs.	513 lbs.	24 per cent.
30-inch.............	1,617 lbs.	2,126 lbs.	509 lbs.	24 per cent.
56-inch.............	1,510 lbs.	2,020 lbs.	510 lbs.	25.3 per cent.
56-inch.............	1,312 lbs.	1,902 lbs.	590 lbs.	31.1 per cent.
50-inch.............	1,288 lbs.	1,797 lbs.	509 lbs.	28.4 per cent.

The wheel shown in Figs. 3 and 4 was designed by the Schenectady Locomotive Works for the Chicago & Northwestern fast mail engines, illustrated in this journal in June, 1899, page 189. The center is 74 inches in diameter and the wheel is 80 inches, over the tire. The weights of the center castings in the rough were 2,461 pounds for the main wheel, and 2,350 pounds for the rear wheel, the finished weights are probably about 8 per cent. less, or 2,264 and 2,162 pounds, respectively. This is a very light wheel; it has 19 spokes of elliptical section. Another design of the same diameter, but with spokes of different shape, is shown in Fig. 5. This drawing represents the main wheel of the Brooks Lake Shore 10-wheel passenger engines, shown on page 344 of the November, 1899, issue of this journal. The weights of these castings in the rough were 2,850 pounds for the main and 2,346 pounds each for the front and rear wheels. The finished weights are 2,670 for each main wheel and 2,175 pounds for each of the others. The front and rear wheels are illustrated in Fig. 6.

Fig. 7 shows the 84-inch wheels with 78-inch centers for the Baldwin compound Atlantic type fast passenger engines for the Chicago, Burlington & Quincy, illustrated on page 141 of the issue of May, 1899. These wheels were made by the Standard Steel Works. A similar wheel for simple and compound engines by the same builders for the French State Railways is shown in Fig. 8. The weights of the centers for the Burlington wheels which are the same for Columbia and Atlantic type engines on that road are 2,882 pounds for the forward wheels and 2,990 pounds for the rear or main wheels, these are finished weights. The spokes of these wheels are 2¼ by 6½ inches at the hub and 1¾ by 4 inches at the rim. The rim is 3 inches thick and lightened between spokes. The wheels for the French engines have the same sections of spokes but are different in weight, the hubs of the French wheels being lighter. Some of the French engines are compound and some are single expansion. The drawing, Fig. 8, shows one of the drivers of the compounds. The weights for the compounds are 2,705 pounds for the main and 2,682 pounds for the rear wheel; for the single expansion engine they are 2,705 for the main and 2,995 for the rear wheel. The hubs of these wheels and the crank pin bosses are cored out for the purpose of lightening them.

An example of recent practice in 50-inch cast steel wheel centers for heavy consolidation engines is shown in Fig. 9. This is a main wheel, the center of which weighs 1,501 pounds in the rough, the front and rear wheel centers weigh 1,335 pounds, and the intermediate, 1,348 pounds. The finished weights are probably about 125 pounds less than these figures.

Fig. 10 illustrates the wheel center of a well-known Atlantic type passenger locomotive which has made a reputation for fast running. The main center, shown in the engraving, weighs 1,993 pounds, while the front center weighs 1,888 pounds. An allowance of about 150 pounds per center should be made for finishing. In Figs. 9 and 10 the hubs are lined with phosphor-bronze, cast in place, for which purpose two dove-tailed grooves are turned in the faces of the hubs. This proves satisfactory for new wheels, but to facilitate repairs it is found to be better to place the bronze liner on the box, which is easier to handle in the shop in making repairs than are the driving wheels.

Cast steel driving wheels made by the Sargent Company in 1897 for the Illinois Central R. R., with 72-inch centers, weighed 2,391 pounds each, and the physical characteristics were:

Tensile strength per square inch..............................	63,400 lbs.
Elongation in 2 inches..............................	38½ %
Reduction in area..............................	47 %

The wheels shown in Figs. 3, 4, 5 and 6 were made by the Pratt & Letchworth Co. of Buffalo. Those for the Chicago & Northwestern were required to have not less than 60,000 pounds tensile strength and an elongation of not less than 15 per cent. in 8 inches. The writer has had the privilege of examining the records of forty reports of tests on cast steel driving wheels made by this firm for the Chicago & Northwestern to these specifications, and the tensile strength runs from 60,480 pounds with an elongation of 25 per cent. in 8 inches to 78,900 pounds and 17 per cent. elongation. The opinion of this firm, based on extensive experience, is that the best wheels are those in which the tensile strength is not high and the elongation is good. The presence of too much carbon has a tendency to increase the tensile strength and reduce the elongation. Steel of 60,000 pounds tensile strength and 15 per cent. elongation as specified by this road is strongly advocated.

The writer recently saw a cast steel driving wheel at one of the leading locomotive works which had been rejected by the inspector on suspicion because of some surface imperfections. The wheel had been "tested" under the drop until it was bent and twisted into unrecognizable shape, but without a sign of breakage. It was of the best of material, and "better than it looked." This brings up the question of testing cast steel for wheels, and it is a difficult one. It is evident that allowance should be made for the fact that the coupon, on account of its size, does not correctly represent the true character of the metal contained in the wheel. Being smaller than the wheels, there is of course a possibility of shrinkage in these castings and they cool more rapidly than the body of the wheel, which gives the coupon a structure different from that of the wheel, and it is believed, a somewhat inferior one. It has been learned from experience that test bars frequently represent a much lower standard than is shown by a similar sized piece cut from a spoke or the rim of a wheel.

A driving wheel is a difficult casting because of the danger of shrinkage stresses between the large and small masses of metal. The castings may never be entirely free from shrinkage stresses, but the fact that driving wheels of this material are so satisfactory reflects great care and skill in the furnace and foundry. The time is at hand for the use of cast steel exclusively for driving wheels.

Page XVI of this issue will interest competent and ambitious young men who are in the motive power department.

LOCOMOTIVE TENDERS.

By William Forsyth.

The contrast between the tenders on English and American locomotives in the past has been marked, and decidedly to the disadvantage of the latter. The English tender, built entirely of steel with large wheels, substantial draft gear with good workmanship and fine finish all over, is an object lesson which locomotive builders in this country have but recently observed. The average American tender is a crude affair, being really a tank car consisting of what is essentially a freight car with a water tank and coal box on top. Recently the tendency has been to follow the English practice, particularly with passenger engines, by making the tender a handsome and substantial structure, and in a few instances the English practice of using three pairs of wheels instead of two trucks, has been introduced with satisfactory results.

The large size of cylinders and boilers of modern locomotives makes it necessary to use a tender of large capacity both for coal and water. While the use of water scoops for tenders renders large water space unnecessary, this appliance is only used where there is a dense traffic, and the capacity of modern tenders may now be said to be 5,000 to 6,000 gallons of water and 8 to 10 tons of coal. The large consolidation engines now being built when cutting off at half stroke consume 4,000 gallons of water every 13 miles, and 5,000 gallons every 16 miles. When cutting off at three-quarter stroke a 4,000-gallon tank will furnish a supply for a run of only 8 miles; 5,000 gallons, 10 miles; 6,000 gallons, 12 miles, showing the necessity of tanks of large capacity if very frequent stops are to be avoided. Large tanks are also used to carry the train past a station where the water supply is poor, and to enable the engine to make sufficient mileage to reach a point where a better water supply can be obtained.

The advantages of six-wheel tenders for passenger engines are, the use of large wheels and the simplicity attending few parts making the construction under the tank frame easy of access for inspection. The reduction in the number of parts connected with an axle and pair of wheels is considerable, as it means two journal boxes with the bearings, lids and attachments, a brake beam with its shoes, lever and connections. The six-wheel tender also virtually disposes of all those parts which are essential to the truck frame. With six-wheel tenders the journals are much larger, 5 by 9 inches, and bearings and other fixtures more substantial, and the rate of wear much less, requiring less attention for repairs.

The six-wheel tender is especially adapted to high-speed engines and has been used in this country without equalizers, and in the fastest service on roads where the track was not up to the best standard. The English tenders are not equalized as a rule and the only object of equalizers is to prevent derailment due to poor track. It is probable that the average condition of American main line track is equal to or better than the English track, and it is certainly better than the English track on which six-wheel tenders, without equalizers, ran for years with safety. On the fast runs where six-wheel tenders are most likely to be used, it is necessary for other reasons to have the quality of the track above the average. Equalizers introduce an additional set of details and for the reasons given above they are not considered necessary. With so few parts and such simple and substantial construction the cost of repairs must be much less than when trucks are used. When a water scoop is used there is more room for its mechanism than is the case with trucks. These are some of the principal advantages in favor of six-wheel tenders.

The high tractive power of modern locomotives renders it necessary to have a substantial draft gear on tenders, and where wooden underframes have not given way to iron or steel, the center sills at least should be steel, so as to secure a solid attachment for the draft gear. With the best practice the whole underframe is now made of steel channels—thus securing a stronger structure and requiring much less expenditure for repairs than a wooden frame. The fear of deterioration by corrosion for a long time prevented the more general use of steel underframes for tenders, but the general use of steel cars at present points to the fact that if steel can be used for freight-car underframes without fear of rapid corrosion it can certainly be used for tenders where the superior strength of steel is especially necessary.

With the demand for more coal space the shape of the flaring coal side above the water space has been changed, and in the large tenders the outside sheets are carried up vertically, making a plainer outline. The extreme width of tenders is now so great that the clearance limits are almost reached by the vertical side sheets and the inclined coal side is no longer possible or desirable. It is, of course, not necessary to carry this coal side around the back part of the tender, occupied by the manhole, and this part may be stopped off by a back board and left entirely clear, without any side beyond the water space, and this form of construction has appeared on recent tenders. It is necessary to place a guard rail of some kind about the manhole to prevent firemen from slipping off, but this is secured in a much simpler and cheaper way by the use of round iron rails than by the use of the sheet skirt at the sides and ends. The use of the latter only results in the accumulation of trash on the back of the tender, which soon gets mixed up with coal and water, and often becomes frozen; it is always a useless dead load, which, to say the least, is untidy. When this space about the manhole is clear and exposed to sight it can be kept neat and clean.

The use of oblong manholes for tenders is becoming general, as their use renders it unnecessary to make a water tank stop at an exact spot, but some margin is allowed in each direction.

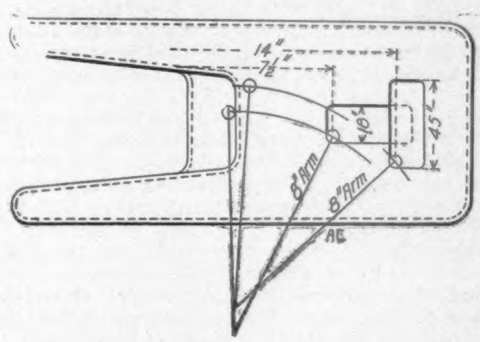


Fig. 1.

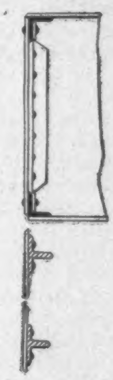


Fig. 2.

It was at first thought by some that this advantage could be best secured by placing the long axis of the manhole parallel with the track, and some tenders were built in this way, but it soon became evident that a larger range could be obtained by placing the long axis crosswise of the track, and this location is now always used where the oblong fixture is introduced (see Fig. 1).

The old method of bracing tanks was crude and flimsy, requiring frequent renewals and repairs. It consisted of cross-bracing about the center of the height of the water leg—using round bars or flat strips with pin connections and crow-feet or angles on the sides. The small section of the parts made them deteriorate rapidly by corrosion and wear, due to constant rattling of loose joints. With large tanks and high sides a much better and simpler form of bracing is now used. One of the best is the use of vertical pieces of heavy tee iron about 3 by 3½ inches thick, spaced about every 2 feet and bearing at the ends on the angle irons at the corners (see Fig. 2).

Tender trucks have been developed and improved to a remarkable degree, diamond freight trucks being no longer considered the proper thing for such an important service. The Fox truck, of ordinary freight types, has been used to some extent, but that company has designed a pressed steel truck

with elliptic springs and swing bolster which is more suitable for the purpose. As it is often necessary for the fireman to stand on the tender while firing, the springs should have an easy motion. It is doubtless true that such heavy loads are carried on elliptic springs with less injury to the track and less wear to the truck and tender frame. The old practice was to have side bearings on the rear trucks and none on the front trucks, leaving the whole load on the front truck to balance on the center plate; but with larger and heavier tenders it has been found necessary to steady the load, and it is now the usual practice to place side bearings on both front and rear trucks.

The adjustment of the height of the rear drawbar and front platform on tenders to different heights of driving wheels was formerly accomplished in a crude and troublesome manner. When new tires or larger drivers were put in, the tender frame was blocked up on the truck in order to get the fireman's platform to the proper height. It was then necessary to let down the rear draft iron or put on a new one of a different pattern, but the use of M. C. B. couplers on tenders has rendered this method undesirable and the tender frame is now maintained at a standard height from the rail and the front platform is changed to suit the height of the drivers. The usual design, for connection between engine and tender, does not admit of adjustment to suit changes in the thickness of tires or diameter of drivers, and there is an opportunity here for an improvement in the front tender draft iron which will so arrange it that it will admit of adjustment of the height of the front draw-bar.

Tender steps and grab handles have also been rather crude in the past, but the use of cast iron steps, with a wide one at the bottom somewhat offset, is now growing more general. This form of tender step was recommended by a Master Mechanics' Association committee, and is illustrated in the proceedings for 1896, page 311, and it is there recommended that to insure safety the form and location of tender steps should be nearly uniform, so that one could in the dark readily locate with his feet and hands the steps and hand hold of any locomotive.

The use of large figures 2 or 3 feet high on the sides and ends of tenders was never justified by any considerations of utility or beauty, and they are gradually disappearing. It is seldom necessary to read the number of a locomotive at a distance of more than a hundred feet and figures 6 or 8 inches high can be easily read at that distance. The numbers on the cabs or sand boxes are also sufficient for most purposes, and the number on the side of a tender is almost if not entirely useless. Figures on the end of a tender 8 or 10 inches high should be sufficient to locate an engine in the round-house when the engine is placed head in—but it is proposed by some roads to leave the numbers off of tenders altogether, and by others to paint the numbers on removable tablets so that any tender of proper type can be attached to any locomotive. On the London & North Western a locomotive illustrated in the January number, page 1, it will be noticed that the only letters on the side of the whole locomotive is the engine number on cab, and there is no figure on tender. An example of a handsome six-wheel American tender is shown on page 22 of the January issue of this journal. This is the Pennsylvania fast passenger engine, Class E 1. The admirably designed location of the steps on each end of the tender and on the back of the engine will entirely satisfy the Master Mechanics' Association requirements already referred to. The coal space on this tender is arranged like that used on German engines, where the sloping coal deck extends clear across the tender, the front portion being level and about 18 inches above the top of the front sill. By this arrangement the coal is constantly delivered by sliding down the incline, to a point most convenient for the fireman.

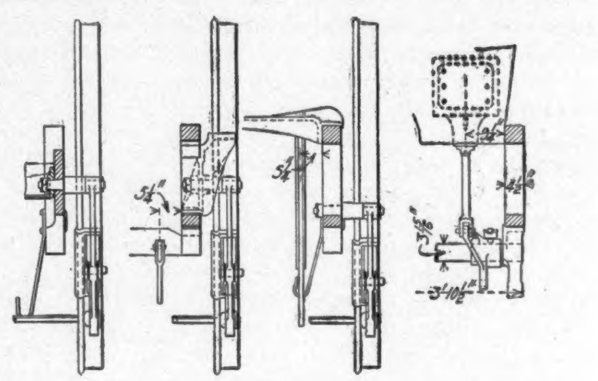
Another tender of exceedingly attractive appearance and good design is that on the new Brooks passenger engine for the Chicago and Alton road, which is illustrated in this issue. In this case the gangway is so narrow that one step casting at front of the tender is sufficient for the engine and tender. This tender is painted a maroon color to match the cars on the Alton day train from Chicago to St. Louis. The lettering and striping are especially neat and in striking contrast with the large ugly figures so often seen in Western tenders.

General plans and details of several modern American tenders will be illustrated in a future article as this portion of the locomotive is usually shown in outline or by photograph and it has not received the attention which its present importance and interest demands.

IMPROVEMENTS IN LOCOMOTIVE DRIVER BRAKES.

The publication of the improved design of locomotive driver brakes in the January issue of this journal has brought out correspondence which indicates that there is to be an improvement in the status of locomotive brakes as a factor to be considered in the original designs of locomotives, and it is beginning to be appreciated that the stopping of fast and heavy trains is one of the most important considerations in their operation.

It was natural that the driver brake should be a rather crude affair during its early life, and that it should be considered as an attachment rather than an integral part of the locomotive because at first it was applied to locomotives which were in service, but there is no reason for perpetuating the positively bad practice now prevalent. The driver brake has not held a prominent place in the minds of locomotive men during the drawing room stages of construction, but this is now rapidly being changed. Only recently has it become necessary to seriously consider the saving of weight in other parts in order to favor the boiler, but this influence is now very powerful, and is likely to effect the greatest improvements in locomotive development. This problem necessitates the most skillful work in connection with details, and one of



Transverse Sections.

the most promising sources of weight saving and weight adjustment is in the driver brakes.

The adjustment of weight whereby the center of gravity is carried as far forward as possible to the relief of the driving wheels is desirable, and this is carried out in designs by the Lake Shore & Michigan Southern for 10-wheel passenger engines, the Pennsylvania on Class H 6 consolidation and E 1, Atlantic type engines, and on the Baltimore & Ohio in 10-wheelers. In our December, 1899, issue the advantages of designing the frames for the direct connection of the brake rigging were clearly indicated. It is evident that if the brake cylinders are carried forward to a convenient location under the front end of the barrel of the boiler, still further advantages will be gained, and these are important enough to command the attention of those who are working on the lines mentioned.

If the brake cylinders are placed near the front of the engine a large proportion of their weight is carried upon the truck instead of being thrown entirely upon the driving wheels, as is the case with the usual location, near the rear ends of the frames. Unusual efforts are now being made to reduce the weight at the rear end of boilers by tapering the sheets and inclining the back heads. There is a further advantage in the forward location of the cylinders because it permits of placing the brake shoes against the rear instead of the front of the driving wheels. Furthermore, the cylinders should be kept away from the firebox in order to avoid the troublesome burning out of the piston packing. All of these recommendations and the retention of the push principle with the absence of stuffing boxes on the brake cylinders are offered by the forward location. It may also be urged that

the cylinders are not liable to injury in derailments or other accidents if they are placed under the front end of the boiler, or, as in the case of the new Lake Shore 10-wheel passenger engines.

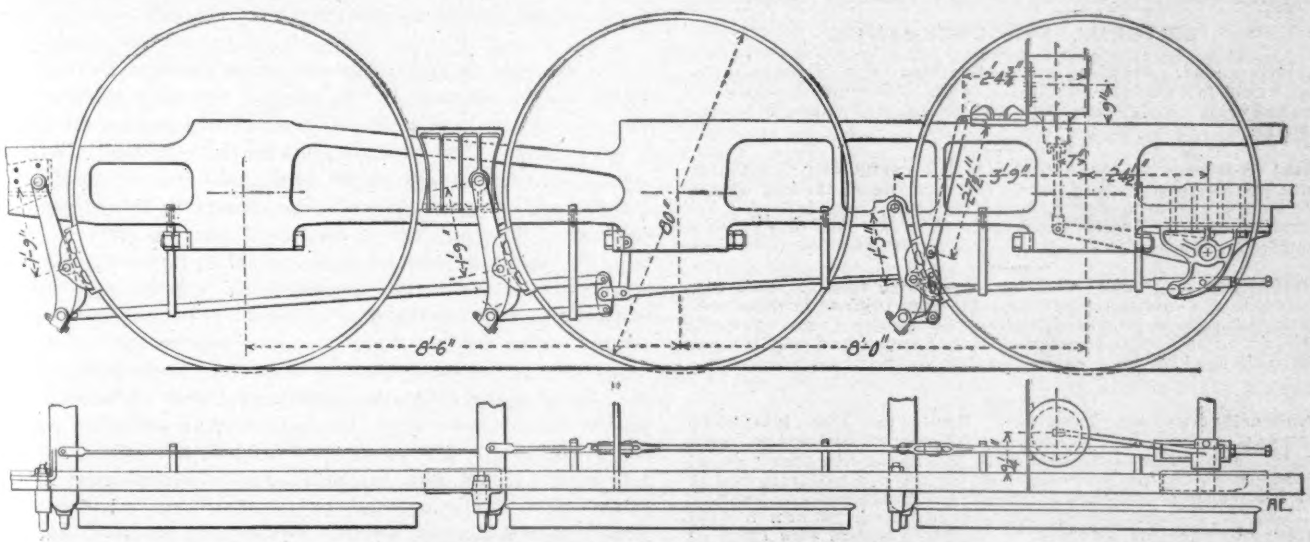
In the present light on the subject, the practice of placing the brake shoes back of the wheels seems to be a great improvement. This plan causes the brakes to press the driving boxes against the shoes, instead of against the wedges, and it gives an upward thrust instead of a downward pull of the shoes upon the hangers. This relieves the springs, and spring hangers form a serious additional load, and these parts may be materially lightened if they are not subjected to it. Spring hangers are subjected to particularly severe service, and Mr. F. J. Cole (issue of May, 1899, page 145) states that even for exceptionally good iron the fiber stress of these parts should never exceed 4,500 pounds per square inch if failures and breakdowns are to be prevented. The stresses due to the application of the brakes undoubtedly play an important part in the life of these hangers, and it seems probable that this influence, in the case of designs with the shoes in front of the wheels, accounts for the very low allowable working stresses.

The accompanying engraving illustrates the brake rigging on the 10-wheel passenger locomotives built by the Brooks Locomotive Works for the Lake Shore, already referred to. It will be noted that the frames, frame braces and boiler supports are used as far as possible for connecting the brake fixtures, necessitating very few additional parts for the attachment of this rigging. This design is an example of excellent practice, but it is evident that it can be improved by a further application of the Higham method of attachment to parts forged upon the frames for the purpose.

It is difficult to locate a push cylinder applied to a 10-wheel locomotive properly unless placed toward the front of the engine without using a long connection between the piston rod and the brake lever, and the parts must be made very heavy to avoid buckling. In a locomotive of this type with large driving wheels, say 78 inches in diameter, it is very difficult to find a place of attachment in the rear of the drivers in the usual manner, so that it may be said that the construction of large 10-wheel locomotives makes the new plan very desirable also from a constructive point of view.

It is exceedingly important to locate the brake shoes as high upon the wheels as possible, and if practicable it would be very desirable to place them opposite the horizontal centers of the wheels. This applies to cars as well as to locomotives. The lack of room between driving wheels renders it necessary to drop the shoes too low in many cases, and the effect of this is probably not fully appreciated. If it were, greater efforts would be made to give the proper amount of room for the shoes. The chief trouble comes from the vertical motion of the engine on the springs which causes the shoes to rise and fall in relation to the wheels. This changes the piston travel and seriously interferes with the efficiency of the brakes, and its effect is of course greater, as the position of the shoes is made lower because the horizontal movements of the shoes are greater than when placed opposite the centers of the wheels where they ought to be. The stroke of the cylinder piston should be kept as short as possible for the sake of economy in the use of air, especially because of the increasing demand for air for purposes other than the operation of brakes. "Air brake parasites" is an apt term for a number of uses of air in trains with which the air brakes have nothing whatever to do, and the question now is how to get enough air for the brakes. Air power is used for bell ringers, sanders, raising water in sleepers, making gas for car lighting (Frost system), running ventilating fans, shaking grates, operating blow-off cocks, pilot couplers and flangers, and opening firebox doors, not to mention all the applications now in use. This is severe on the air brake, especially if it is not safe-guarded against the wastefulness of long piston travel.

An illustration showing the importance of putting the brake shoes high up on the wheels was seen some time ago when a stock train came into a terminal and discharged its load. The engine which had hauled it over the division when loaded could not start the empty train out of the yard. This was because the adjustment of the shoes was close and the shoes were low on the wheels. The relief of the load raised the cars on their springs enough to bring the brake shoes against the wheels and hold them as if they were under pressure from the cylinders. This requires attention in the design of cars and locomotives. It cannot be remedied after construction.



A Good Example of Driving Wheel Brake Rigging.
New Ten-Wheel Passenger Locomotives—L. S. & M. S. Railway.

THE MASTER MECHANICS' AND MASTER CAR BUILDERS' CONVENTIONS FOR 1900.

The annual convention of the Master Car Builders' Association will be held at Saratoga, N. Y., commencing Monday, June 18, and the Master Mechanics' Convention will open Thursday, June 21, lasting through the week. The dates have been changed in order to bring the two conventions within one week. The Grand Union Hotel will be headquarters, the usual rates having been made for members of the Associations and their friends. The United States Hotel will be open and those desiring dignified comfort and quiet will be glad to avail themselves of the opportunity of stopping there.

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Contributions.—*Articles relating to railway rolling stock construction and management and kindred topics, by those who are practically acquainted with these subjects, are specially desired. Also early notices of official changes, and additions of new equipment for the road or the shop, by purchase or construction.*

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The brief note entitled Master Mechanics Wanted, on page 16 of our January issue, resulted in filling the positions referred to, and in bringing out a number of promising men whose names are on file in our editorial rooms for the benefit of inquirers who need assistants.

A number of railroads are seeking good men for responsible motive power positions, and we have been repeatedly solicited for names for these positions. There are many capable young men who are not well known and we cheerfully accept the task of bringing competent and reliable men before the higher officers who inquire. See page XVI, this issue.

In another column Mr. Squire suggests a practical study of the movements of the sheets of a locomotive firebox for the benefit of knowing how the stresses due to expansion and contraction act. Actual measurement of the movements of the sheets would throw light on a very obscure subject, and it is to be hoped that the suggestion will be carried out. Our correspondent presents the subject in a most satisfactory way, which includes a sketch from which the recording device may be made. It ought to be applied to fireboxes of various forms, to those which are long and deep, those which are shallow and short, and, in fact, to all kinds of stayed fireboxes. The form used on the Lehigh Valley and recommended by Mr. F. F. Gaines, on page 9 of our January issue, may be expected to give favorable results. This is now largely a matter of opinion, but a few simple experiments will show which is the best form. This subject is important enough for a thorough investigation by the Master Mechanics' Association.

The increasing weights of passenger trains and the increasing severity of service are becoming burdensome to those who are responsible for the designs of locomotives to handle them. While there may be, and probably are, economical advantages in the use of the most powerful locomotives, it is a question whether some of the present pressure should not be applied to other questions such as the provision of interlocking plants at all crossings covered by fast runs and in the improvement of locomotive water stations. In a remarkably fast run recently recorded in these pages, two crossing stops are noticed. The effect of these stops on fast trains is easy to comprehend and it seems equally clear that the expense of stopping all trains at such points should be appreciated. The engineering department is often behind in the strength of bridges to carry the engines which are now required and it seems appropriate to direct attention also to the non-interlocked crossings as one factor in the present necessity for heavy engines.

The struggle for a proper solution of the trouble over the status of the engineer in the navy is far from being ended. The line officers have won their case and the engines are now—if we understand the situation—placed in the hands of enlisted men. The real purpose of the personnel law was to solve the difficulty by insuring that all line officers in future shall be engineers. This appears to have been very satisfactorily settled, but owing to a recent order issued by the Assistant Secretary of the Navy, the commissioned officers are relieved from engine room watch duty. The navy and the nation cannot but suffer for this, and yet it may require another war to right it. The lesson, learned at Santiago, by both Spain and the United States, that the success of a fleet of modern war vessels depends more upon the engineer than any other human factor, is lost if this law is not carried into effect, and we may expect to see Admiral Melville's ominous words on this point before the American Society of Mechanical Engineers come true. When the country awakens to the fact that the present status of the real engineer in our navy is exactly that of the Spanish in the late war something will be done.

The skein test for color blindness is known to be defective, yet it is probably used more than any other, and presumably through ignorance. Prof. Scripture and Dr. C. H. Williams gave most valuable information on this subject before the New York Railroad Club last November, and the complete discussion has now become available in the proceedings of that organization. Next to normal color vision, at least, if not first in importance, is the standardization of the colors, particularly of red and green. It is generally the custom to accept signal discs from glass manufacturers without tests of any kind, and in this discussion it was proved that many reds are used which are dangerous because they let the green through as well as the red. Every signal engineer or officer in charge of signals should use the spectroscope to guard against this dangerous glass. These instruments are inexpensive and are made in sizes convenient for the pocket. When one of these so-called red glasses is held before the instrument the green rays and part of the blue will appear always with the red. The correct red glass shuts off all rays except the red and these are seen distinctly. The good and dangerous reds are very similar in appearance, but one is red while the other is a mixture of red and green. A similar, but less dangerous, trouble occurs with green glass, some of the greens being distinctly blue.

The increasing weight of locomotives is strikingly shown in this issue by the table of comparison of the weights of locomotives built by the Brooks Locomotive Works in the years 1891 to 1899. These figures are from one building firm only, but it is believed that they fairly represent the practice of the eight years. The most striking figures given are for the average weight of engines and tenders in working order and the average weight of the engines alone. The former figure showed an increase of 85,783 pounds per locomotive and the latter an increase of 53,135 pounds. These figures are unexpectedly large and very significant, because they indicate corresponding advancement in power and improvement in operation. These statistics would astonish those who considered the limits of weight to have been reached years ago. There is no ground for prediction as to the weights of the future, but this increase carries the impression of the very great importance of making the weight count to the utmost in power capacity. Unless the increased weight is productive in this way it is of no value. What is now most needed is improvement in the making and the use of steam also in counterbalancing, so as to permit of using greater weights on driving wheels without increasing the destruction of rails.

SYSTEMS OF ELECTRIC DRIVING IN SHOPS.

The present indications are that during the next few years all new shops and many remodeled old ones will have some, if not all, of the machines driven by electric power. Long lines of shafting often require from 60 to 75 per cent. of the total power to overcome friction, and it is safe to count upon enough saving in power by the introduction of electric motors to furnish light for the same shops. The question of fuel economy, however, is not the most important one, because with wasteful systems the cost of power is usually about 2 per cent. of the cost of labor. The important question is to get the most out of the plant. The Baldwin Locomotive Works several years ago expended about $65,000 in electrical machines and the cost is saved every year in the saving of labor. The Chicago, Milwaukee & St. Paul Railway installed an electric motor to operate a turn-table. The cost was $550, and it saves $1,600 per year in wages.

Electric motors are accepted as offering valuable means for increased shop output; they are reliable, efficient and worthy of confidence; they are ready to respond instantly to a demand greatly in excess of their rated capacity, and they have the further advantage of accurate and easy adjustment of speed. It is not easy, however, to learn the best method of obtaining these advantages in practice. Each individual plant has its characteristics to be considered, and one of the limiting factors in the adoption of a plan of electric driving is the relative cost and efficiency of large and small motors. Seventy-five dollars per horse power for one-horse power motors and $20 per horse power for 50-horse power motors may be taken as an approximately correct proportion.

It is desirable to use as few different sizes of motors as possible because of the repairs. These considerations lead to the comparison of four systems of motor arrangement:

1. Individual motors.
2. The group system.
3. Comparatively long lines of shafting, each driven by its motor.
4. A combination of the individual and group systems.

Individual Motors.

Where the tools are relatively large this plan reduces the losses of transmission to a minimum and it also permits of any desired use of cranes and machinery for handling parts and finished work to and from the machines. It avoids all the troubles caused by belts, but the cost is high and the motors will seldom be of greater capacity than 5 horse power. The power of the motor must, of course, be sufficient for the greatest load ever put on the machine and for a large part of the time much less power is required, which means rather inefficient operation of the motors. This plan also requires a large number of different sizes of motors, for which extra repair parts must be kept, and with small motors the repairs are much greater in amount than with larger ones. This system, however, uses no power except when the machines are running, which is not true of any other system.

There is no system which permits of getting so much out of the machines as that of individual motors, and in some cases this will outweigh all other considerations. With a direct-connected motor it is possible to obtain more perfect speed control than can be had in any other way. The full capacity of the tool is always available at a movement of the hand and the machine may be started, stopped or reversed by the attendant without changing his position. Belt shifting is not difficult, but it is one of the little things that men will not do unless it is necessary, and a little hand switch to control the speed will be used when a belt would not be shifted.

Most tools are limited in capacity by the system of driving with which they were originally fitted, and the usual range of speeds is very small. This is the only system which offers this very desirable speed and power control for each machine, and it counts powerfully in the output of a shop where it can be used.

The Group System.

This plan recommends itself where the individual machines are not large enough for independent motors and where improved transmission without too large a capital outlay is sought. Shops and factories with no large tools and with large numbers of small-powered machines must necessarily come under this system. It does not do away with shafting, but it permits of cutting the shafting into convenient lengths and avoids what is probably the greatest difficulty with shafting, the friction of long lengths on account of their liability of getting out of line. The motor driving a group of machines does not need to have a capacity equal to the sum of the maximum possible demands of all of the machines, because it is safe to count upon some of them as being idle or requiring only a small amount of power. The electrical installation of the Baldwin Locomotive Works has the proportion of 1,300 horse power in the generators to 3,500 in the motors, and it seems to be sufficient, as the average horse power at the switchboard is but 1,000.

The groups may be arranged with a view of running certain of them overtime in order to keep up with the rest of the plant, and all of the machines required for certain overtime work would be put into that group. This system renders the selection of motors comparatively easy and has the advantage of requiring the minimum number of different sizes; two sizes, 15 and 25-horse-power motors will suffice for many large shops. The groups may be arranged to have a surplus of power in each at the start in order to provide for expansion. If the load eventually becomes too great for the smaller size, one of the larger ones can be substituted.

Motors on Long Line Shafts.

While a number of cases of this arrangement are in successful use, the objection to it is that there is little diminution in the belting, and, in fact, no advantage over the usual steam drive, except that the steam plant may be concentrated in one place for several buildings or departments. It is a great advance over the distribution of steam engines all over a plant, but it does not bring out the best possibilities of distribution of power by electric motors. Two motors may run a shop or department, one being at the center of each side of the building and connected each way by clutches to the shafting. This permits of running one-quarter of the shop alone, but it involves running long shafting and many idle belts in order to reach a few machines for overtime work. The cost of the motors is less, but their efficiency is not sure to be higher because of the lack of flexibility of the system. This plan does not accommodate good crane service.

Combined Individual and Group System.

By running the heaviest and largest machines by direct-connected motors, stopping at those requiring less than about

5 horse power, and grouping the smaller machines to motors of from 5 horse power up, a very satisfactory system may be devised. This is the one followed at the Baldwin Locomotive Works and in a number of large establishments. It is flexible enough for adaptation to all except extraordinary conditions.

Determination of Power Required.

The indicator affords the readiest and most reliable information concerning the amount of power required. In applying motors to an old shop the full load of the shop may be ascertained at the engine by indicating, and the sizes of the sections or groups may be determined by cutting off portions of the shop successively at the shaft couplings. This will probably be necessary for each individual case, particularly where the groups involve much belting and shafting. For electric drives in new shops there are few reliable data available to the reader and the best plan is to entrust such a problem to the information and judgment of a reliable electric machinery concern. We expect to have more to say on the determination of the power required for installing motors in old shops in a future issue.

CORRESPONDENCE.

MASTER MECHANICS WANTED.

Editor American Engineer and Railroad Journal:

The editorial entitled "Master Mechanics Wanted," in the January issue of your paper, induces me to ask the question: How can a man in a subordinate position on a railroad find out that there are positions unfilled on other roads ?

A man in such a position usually does not have the opportunity to become known to the officials of other roads who may have vacancies to fill, and his immediate superiors may often consider it to their interest not to recommend a good man for a position elsewhere, so as not to lose his services on their own road and have to seek new help themselves.

Jan. 4, 1900. O. A.

HEATING SURFACE AND WEIGHT ON DRIVERS.

Editor American Engineer and Railroad Journal:

I think there is an error in the table at the foot of the first column of page 12 in your January issue. In the third line at the left the words "per square foot" should have been omitted. If I understand your purpose, the table should read as follows:

	Union Ry. Consol. Pittsburg.	I. C. R. R. Consol. Rogers.	I. C. R. R. 12-wheel Brooks.	D. & H. Co. Consol. Schenectady.	L. V. Consol. Baldwin.	L. S. & M. S. 10-wheel Passenger, Brooks.
Weight on drivers in lbs ...	208,000	198,000	193,200	157,500	202,232	133,000
Total heating surface	3,322	3,203	3,500	3,349	4,103	2,917
Weight on drivers divided by heating surface........	63	61.2	55	47	49	45.5

Without having given this subject much attention, I had always thought that the relation between the boiler power and total weight was the important one, as this would be likely to show the excess in the amount of dead weight of 10-wheel and 12-wheel engines over moguls and consolidations. My sympathies were with the moguls and consolidations, but of late I have concluded that extra dead weight occasioned by the additional wheels for a 4-wheel instead of a pony truck is not the most important consideration in this case. If the extra pair of wheels means more heating surface, and consequently more power to put steam into the cylinder at critical point on the road, it is folly to object to their weight. The meat of this question is how much boiler power is to be had for a certain weight on drivers, and I believe your basis to be correct.

The chief engineer fixes the limits of the weight on drivers, and this fact often determines whether an engine shall be a 12-wheeler or consolidation, a 10-wheeler on an 8-wheeler; because, if the boiler needed is part on the smaller number of wheels, the weight would exceed the limits given.

I have made quite a number of comparisons on the basis of weight on drivers divided by the total heating surface, and the results are surprising. They indicate that there is no idea of uniformity in the practice of the railroads or the locomotive builders in what I believe to be the vital factor in locomotive power, viz., heating surface. The calculations for passenger and freight engines are enclosed.

January 9, 1900. F. D. C.

[The passenger engines only are given in the table which we reproduce. These have been worked up with considerable pains, and, as the engines are nearly all well-known designs, the comparison is valuable.—Editor.]

Heating Surface Comparison of Passenger Locomotives.

Road.	Type of Locomotive.	Road Class and Number.	Weight on Drivers. Divided by Total Heating Surface.
P. R. R.	8-wheel	D—16a	48 6
N. Y C.	"	I—928	45.7
Big Four	"	201	39.3
C. R. I. & P	"	1101	41.7
Ill. Central	"	961	44.3
C. & N. W	"	A—908	41.7
C., B. & Q.	"	M—550	46.9
C., B. & Q.	Columbia	N—1590	52.2
A. C. Line	Atlantic		36.0
Wabash	"	G—	38.8
L. Valley	"	664	39 4
C., B. & Q.	Mogul	H	63.2
Gt. Northern.	10-wheel	150	48.7
G. T. Ry	"	999	67.4
Southern	"		50.3
Wisconsin Central	"	227	50.5
B. & O.	"		52.5
N. P.	"	P	45.0
Ill. Central	"	376	58.8
M. C.	"	433	58.1
L. S. & M. S.	"	1 7	47.2

STAYBOLT PROGRESS.

Editor American Engineer and Railroad Journal:

Your article on staybolt progress in the December issue and the communications published in the January issue, have covered all points except one in the study of the life of staybolts. This point is the actual movement of the side sheets and firebox sheets relative to one another, due to the differences in temperatures of the two sets of sheets and the enormous fluctuations of temperature in the firebox itself. The only published record that I have any knowledge of, referring to this subject, is that found on page 27 of the twenty-seventh annual proceedings of the American Railway Master Mechanics' Association for 1894. The committee report on "Cracking of Back Tube Sheets" quotes from a paper read before the Institution of Naval Architects by Mr. Yarrow. This paper discusses the movement of the tube and crown sheets under heavy firing and the method adopted to relieve the stresses of these sheets due to expansion. The relative movement of the crown stays through the top casing sheet is given as being equal to the thickness of a penny (English) which would about 3/32 inch. This is the only experiment, I believe, which has been made to determine the actual movement of sheets relative to each other. No definite data being given, we can only base our deductions on this test in a general way. They show, however, that the crown sheet for some 8 or 10 inches from the front end was supported entirely by the tube sheet, as the stays were free at the point referred to, having moved outwardly through the casing top sheet. From the information contained in this article we cannot determine definitely whether the next succeeding rows of roof stays back of the second row were in tension or compression. Following this line of reasoning, it would seem that the first few rows of radial stays or crown bars with sling stays were in compression and not in tension for which purpose they were designed. This, then, must be true of any type of boiler with stayed crowns.

In this connection I would quote some recent history. It was recently proposed to the writer by a locomotive builder to alter the details of the first two rows of sling stays on a crown bar boiler, to allow for expansion, by elongating the holes in the

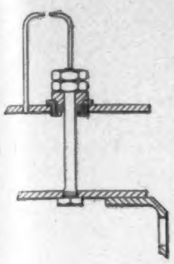


Fig. 1.

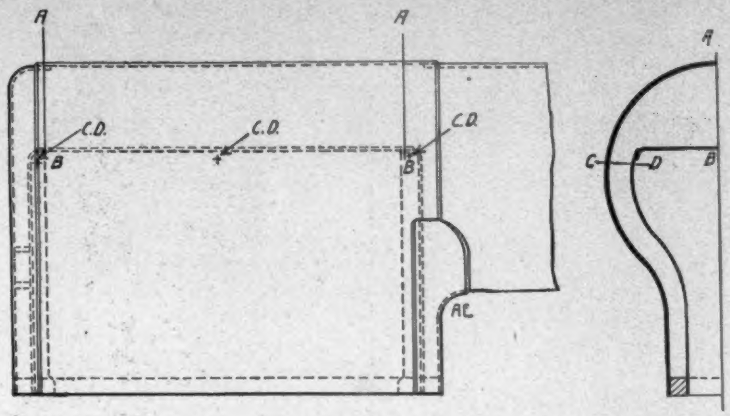


Fig. 3.

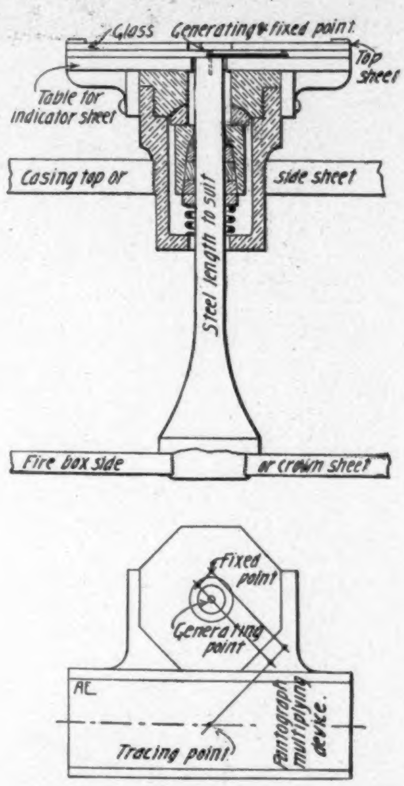


Fig. 2.

lower ends of the stays ⅛ inch. Here we have an unconscious approval of the proposition that the first two rows of crown sheet stays do not stay, and that in view of the fact that the steam pressure carried is 180 lbs. per square inch. The question that now presents itself is: Of what use are the stays on the crown near the tube sheets and door sheets?

Mr. Sanderson's communication of last month covers the question of expansion of firebox sheets pretty thoroughly and presents various points of interest in the nature and location of the line of fracture of staybolts. He refers also to the fact of excessive local heating causing unusual and unlooked for strains in sheets and staybolts, and among ofter things cites the irresistible forces at work due to expansion. Prof. Goss in a recent article before one of the Eastern railroad clubs also quotes some stupendous figures on this same subject.

We have arrived at the point where the concensus of opinion is that in the sheets of the firebox of an internally fired boiler numerous unknown stresses and movements of sheets exist, yet there is no record of these having been studied logically nor are these conditions allowed for in new designs.

The nearest approach we have made to this subject is the vibratory test of staybolts. It is shown that these investigations have developed better practice and lengthened the life of stay bolts. These tests are assumed to give the material an arbitrary deflection of ⅛ inch vertically or in one direction only. The test proved certain facts, and, as shown in the December issue, the number of vibrations any stay bolt material would stand varied with the relative position of the internal structure and the direction of the bend or vibration. The logical result of these tests points to the revolving tests as being the most rational, as is suggested by your article.

We now have two important points forcibly brought to our notice: First, that the firebox sheets "do more" to a very appreciable extent, and, second, that stay bolt material of a certain form of structure gives excellent results, shown by service and vibratory tests. It appears to the writer, second, that the conclusions to be reached from the information at hand is to assume that the movements of expansion due to temperature fluctuations are not in any given direction at any certain point, but that this movement may be in any direction radiating from this point, and that the proper way to test stay bolts would be by the revolving method. The other points at issue, such as riveting and heading stay bolts, loose and tight fits in sheets and the thickness of the sheets themselves, are vital and should be considered carefully in design and building.

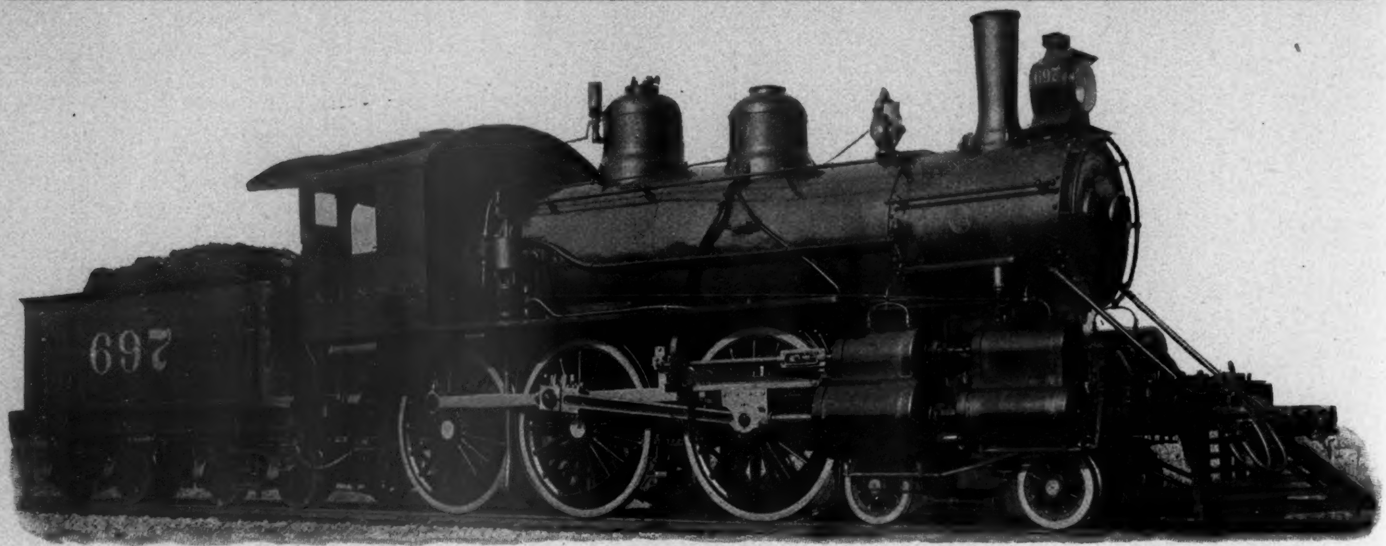
Assuming, then, that there is unequal expansion in the various parts of the firebox sheets and that these expansions and stresses are cumulative, would it not be well to inaugurate a study of these movements as being in line with "stay bolt progress" and progress of boiler design? To advance this subject a step further, I hand you a few sketches of a device designed to record the relative movements of the sheets of the boiler in regard to one another. In this design it is proposed to place in the crown and side sheets of the firebox at the points A B an C D marked in Fig. 3 a fixed steel stud, designed as a beam of uniform strength for the given or required length. The stud is to pass through the casing side or top sheets in a stuffing box provided with metallic packing in such a manner that it will be free to move in any direction due to the movement of the sheet to which the stud is attached. A recording mechanism of pantagraph construction is shown to multiply the motion definitely, say 10 times, in order that the direction and extent of movement can be readily studied. As shown, the device is intended for recording movements in a horizontal or vertical plane, according to the position of the stud on the side or crown sheet. For studying the complex motions of the crown sheet at the junction with the tube or door sheet as at A B, Fig. 3, a second pantagraph could be attached to give the record in a plant parallel with the axis of the stud. A careful design of details and as careful calibration should make a device of this nature an exceedingly valuable piece of apparatus in the study of boiler design.

The sketches presented are given as a suggestion for a line of investigation. If anyone has already investigated on this line and withheld the information, he should at once discover himself so that the work can be prosecuted from the point where he left off.

The writer would hazard the opinion that an investigation on the line suggested will upset a large number of preconceived notions on boiler design and will go a long way toward starting us on the right track to successfully design a boiler that is theoretically and practically correct.

January 17, 1900. WILLIS C. SQUIRE, M. E.,
Atchison, Topeka & Santa Fe Railway.

We learn that Manning, Maxwell & Moore, whose principal offices are at 85 Liberty Street, New York, are compiling a new catalogue devoted exclusively to the illustration of iron-working machine tools. Those who have new tools that they would desire to have illustrated in this catalogue should immediately communicate with Manning, Maxwell & Moore at their New York office, marking their communication "Catalogue Department," which will insure its receiving prompt attention.



Four-Cylinder Tandem Compound Locomotive—A. T. & S. F. Railway

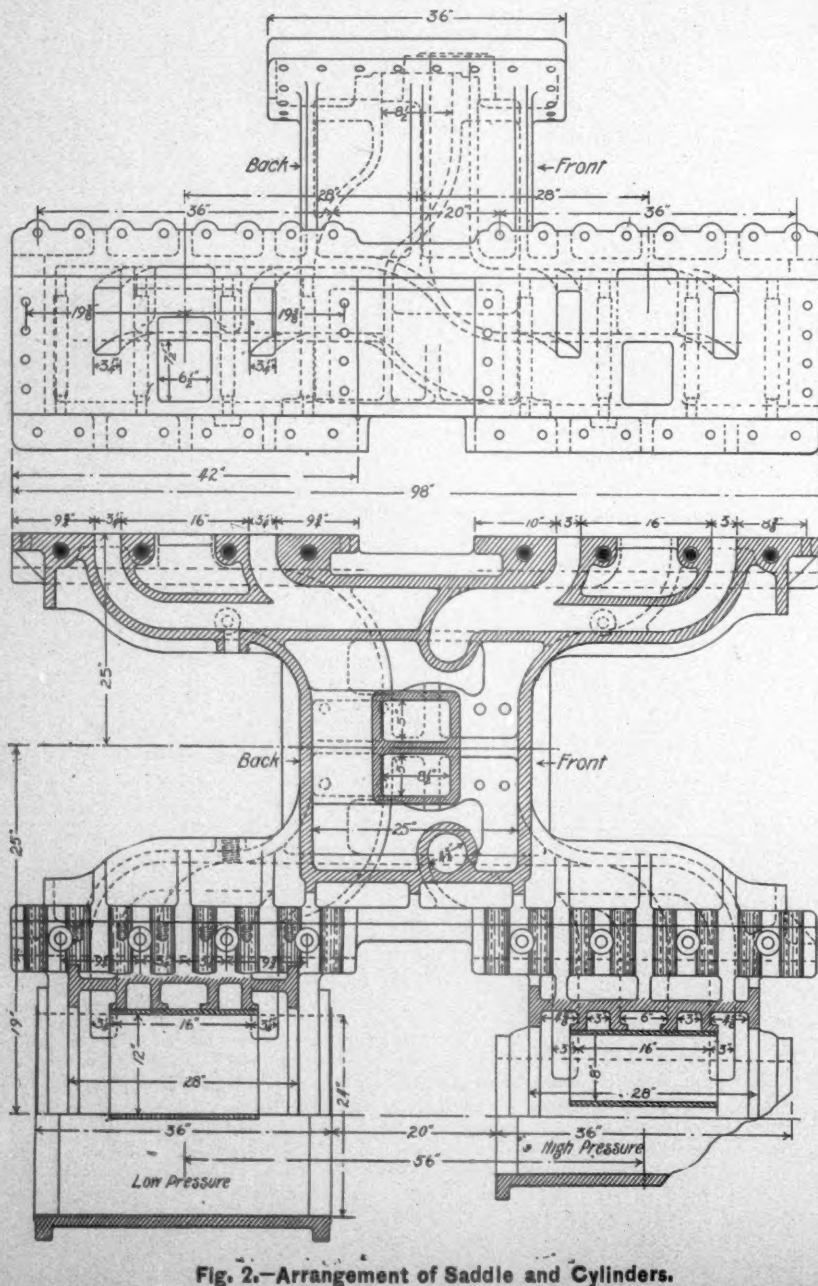


Fig. 2.—Arrangement of Saddle and Cylinders.

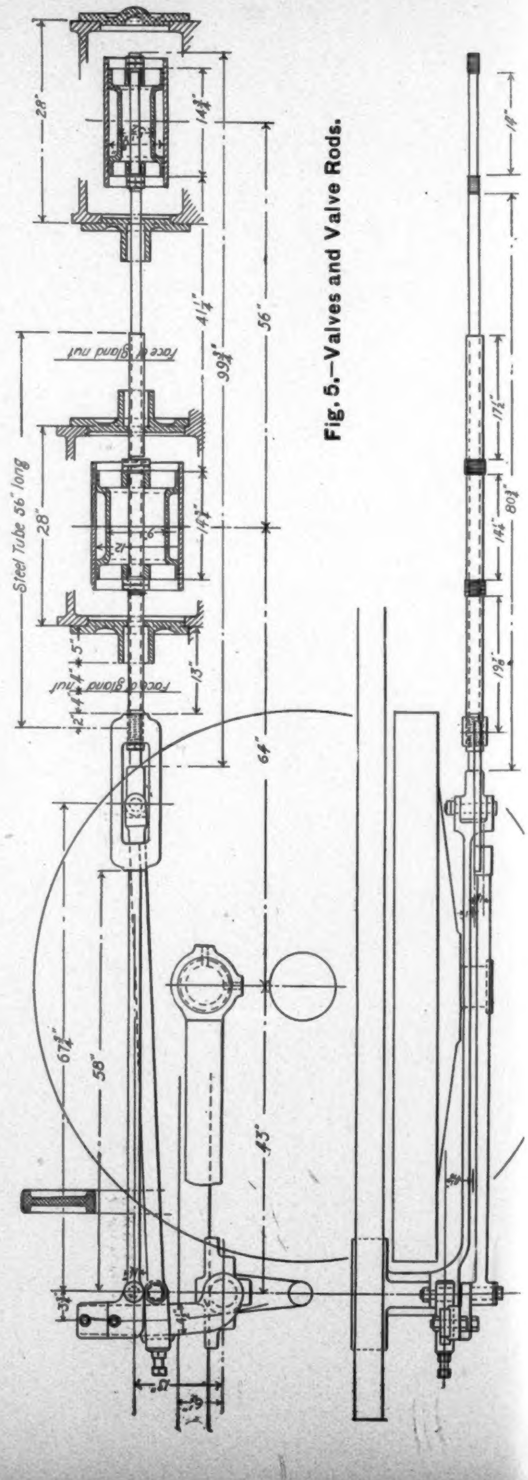


Fig. 5.—Valves and Valve Rods.

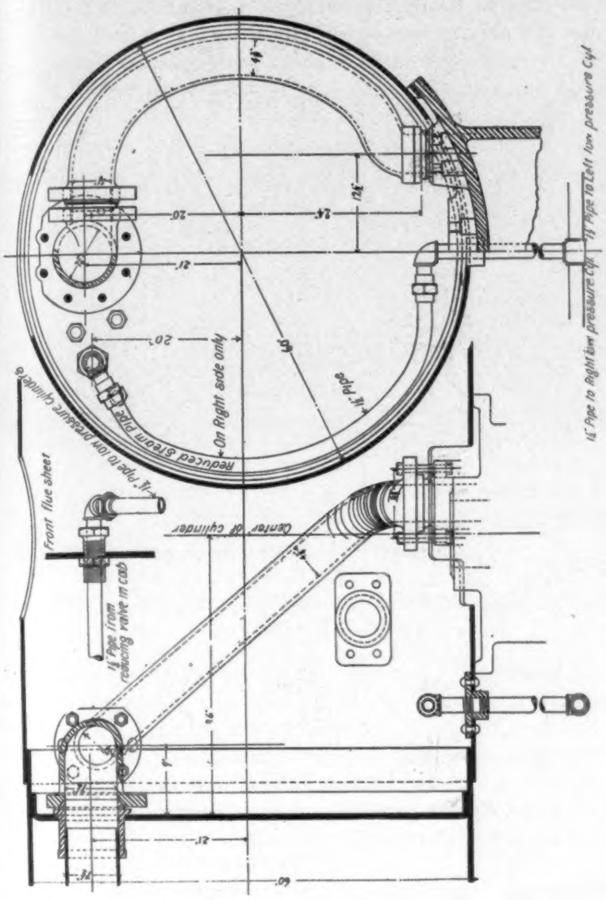


Fig. 4.—Arrangement of Steam Pipes.

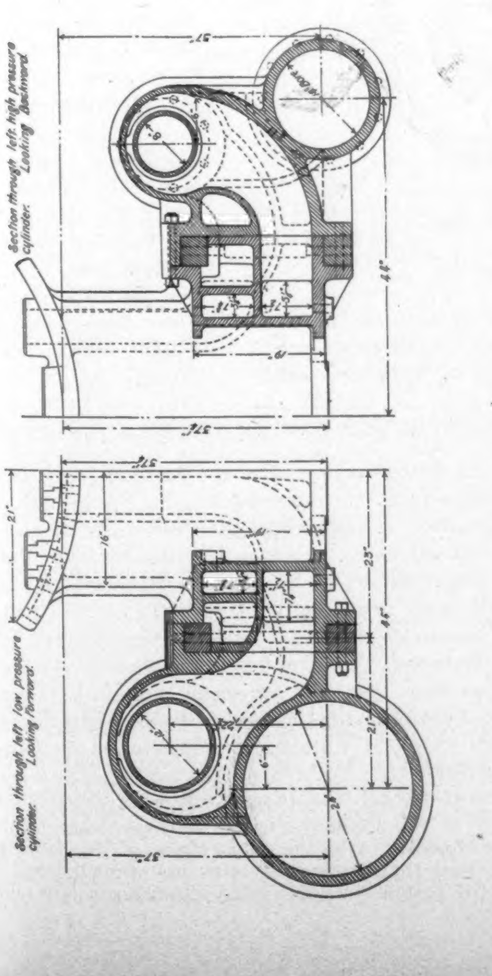


Fig. 3.—Transverse Sections of Cylinders.

FOUR-CYLINDER TANDEM COMPOUND LOCOMOTIVE.

Atchison, Topeka & Santa Fe Railway.

The principles of the tandem type of four-cylinder compound locomotive as worked out and patented by Mr. John Player, Superintendent of Motive Power of the Atchison, Topeka & Santa Fe Railway, were described on page 211 of our issue of June, 1899. At that time the application had been made only to freight locomotives, but it has now been applied to ten-wheel locomotives in passenger service, one of which is shown in the accompanying engraving from a photograph. The chief features of this design are the tandem arrangement of the cylinders, piston valves without packing rings and an arrangement of the attachment of the valve stem for the high-pressure cylinder to its rocker arm in such a way as to permit of adjustment of the cut-off in the high-pressure cylinders to change the ratios of expansion.

The saddle casting has a narrow portion at the center between the frames, and enlarges at the frame to a length of 98 inches on each side, and the cylinders are bolted to the frames and the saddle casting independently with a space of 20 inches between the ends of the cylinders. The arrangement of the steam and exhaust passages is indicated in Fig. 2. Fig. 3 shows half sections through one of the low and one of the high-pressure cylinders, respectively. Fig. 3 shows the arrangement of the steam piping in the front end, including the small pipe for admission of high-pressure steam to the low-pressure cylinders in starting. The valve gear back as far as the rocking shaft is seen in Fig. 5. This illustration shows the method of working the high-pressure valve by a stem which passes through the hollow stem of the low-pressure valve. The high-pressure valve stem connects to a rod attached to its upper rocker arm with an adjustable attachment clearly indicated in the drawing. The valves are in the form of hollow shells without packing of any kind and the admission of steam is from the ends.

The cylinders are 14 and 24 by 28 inches; the driving wheels, 77 inches in diameter; the heating surface, 1,923 square feet; grate area, 26½ square feet, and the boiler pressure, 200 pounds. The weight of the engine is 169,000 pounds, of which 123,000 pounds are on the driving wheels.

This design appears to be very successful on this road. It has demonstrated the possibility of omitting the packing rings from piston valves and has shown the possibility of adjusting the ratio of expansion by varying the travel of the high-pressure valve independently of the low-pressure valve.

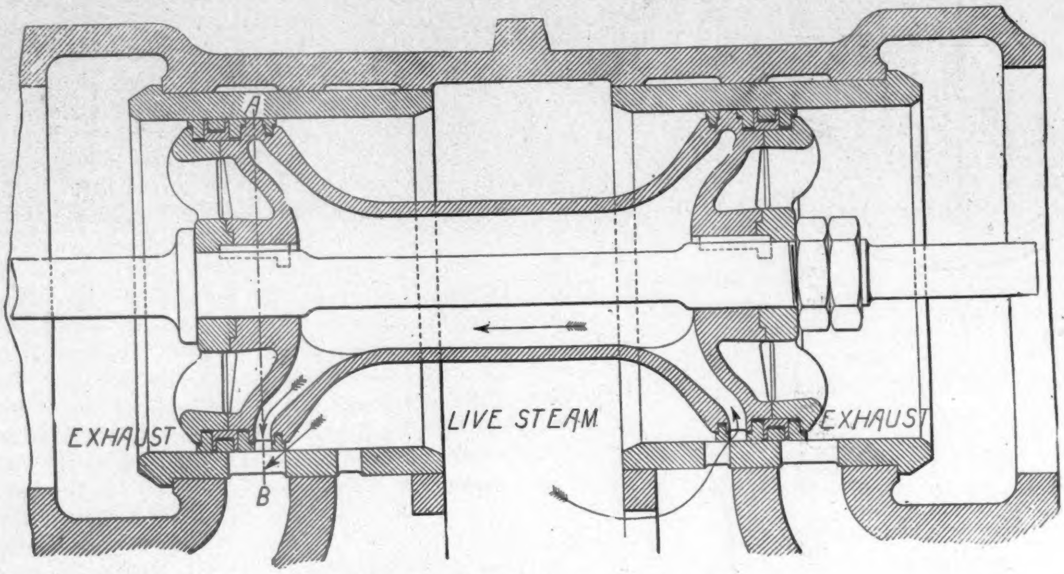
We are indebted to the "Railway Master Mechanic" for these engravings.

The typical dimensions for standard box cars has occupied the attention of the American Railway Association with the result of proposing the following: Length inside, 36 feet; width inside, 8 feet 6 inches; height inside between the top of the floor and the under side of the carlines, 8 feet. A committee of the Central Railroad Club reported at the January meeting approving all of these dimensions providing certain roads would increase their clearances, and suggesting a reduction of height to 7 feet 9 inches if they should remain as at present. This looks rather promising, and it is to be hoped that the Association's recommendation will have the weight it deserves in the final decision.

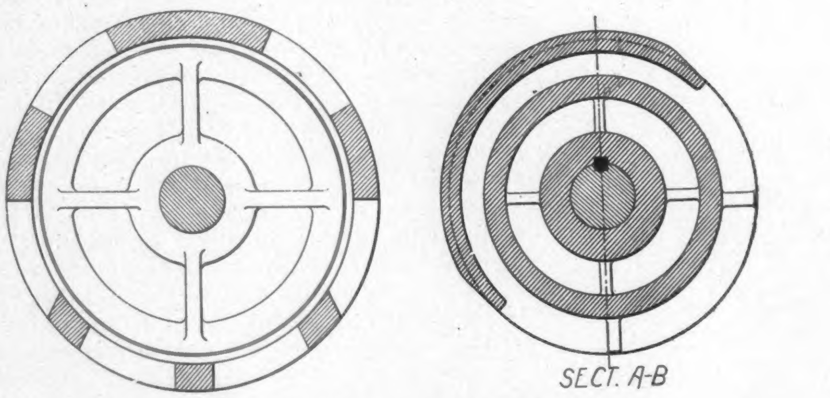
Another record-breaking run of the "fast mail" train of the Burlington road was made a short time ago. The train, pulled by engine 1592, left Burlington, Iowa, 36 minutes late, and arrived in Chicago on time. The distance is 206 miles, and was covered in 209 minutes, including all stops. The run of 83 miles from Mendota to Chicago was made in 76 minutes—the best time ever made between those points. The 46 miles between Mendota and Aurora was covered in 39 minutes. Nearly all the way there was a heavy head wind and the train was unusually heavy.

PISTON VALVES WITH ALLEN PORTS.

Objection has been made against piston valves because of the difficulties in applying to them the principle of the Allen port. The design illustrated was prepared by Mr. Chas. M. Muchnick, of the Compagnie de Fives-Lille, France, to suit the dimensions of locomotives of the Pekin-Hankow line in China, to meet this objection. Mr. Muchnick, believing that it is not at all improbable that the same objection has been made by advocates of the Allen valve in this country, sends us the drawings to illustrate the valve as a suggestion.



Muchnick's Piston Valve with Allen Ports.



Sections of Piston Valve with Allen Ports.

The construction of the valve is clearly indicated in the drawings and requires no detailed description. It differs very little in form from the valves of the Brooks Locomotive Works, with the exception that instead of the hollow open-ended cylinder of the Brooks designs this one is closed, except for the valve ports at each end and the openings for the valve rod which are cored out. There is a marked difference in the packing, however. In the French valve the packing is in the form of spring rings of small cross sectional area to make them flexible in order to reduce the friction against the valve bushings as much as possible, and yet insure steam-tight joints. Apparently no effort is made, except in accurate fitting, to prevent steam from getting inside the rings to set them out against the bushings.

Mr. Muchnick, commenting upon the design, notes that, while this valve embodies all of the virtues of the slide valve of the Allen type, it also overcomes some of the defects of that valve; for example, the breakage of valves due to imperfect placing of the cores, increase of weight and of total size and area of the plain valve. Also, since the exhaust passages, when piston valves are used, are made considerably larger than with slide valves, it may be supposed that the greater back pressure due to insufficient exhaust opening in the latter to exhaust the greater amount of steam admitted into the cylinder on account of the double port opening cannot occur when the Allen principle is applied to the piston valve.

The plan shown takes live steam at the center of the valve like the piston valves in use on the Norfolk & Western Ry.

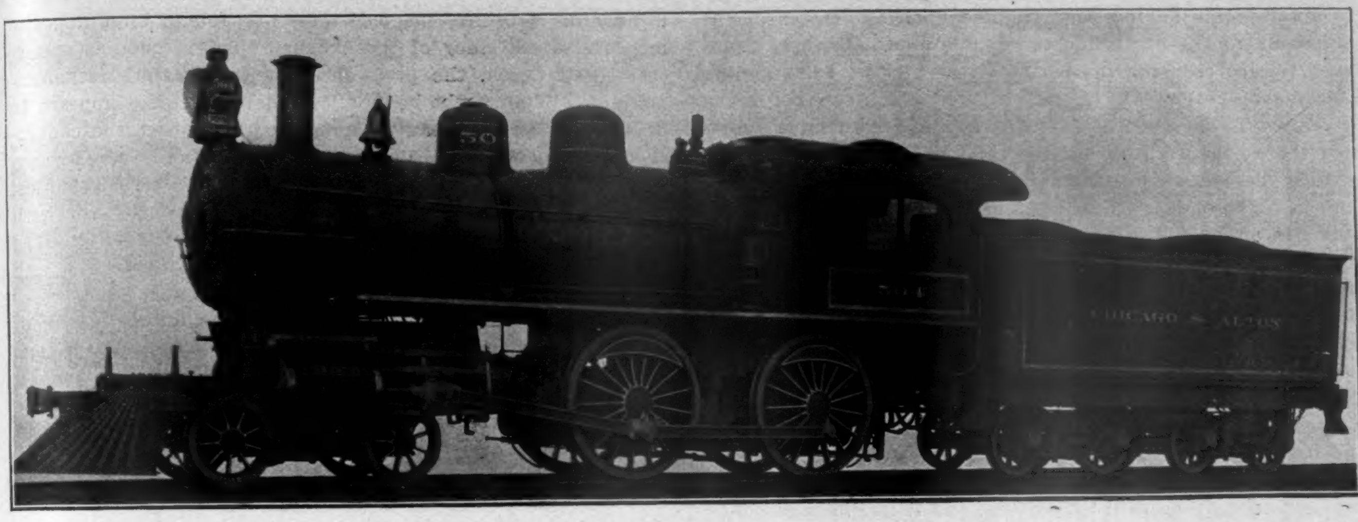
The increase of power of the engine due to the improved balancing of the piston valve is one of the strong points, and if this design should add to this the advantages of the Allen port for improving the admission of steam and also reduce the back pressure and the weight of the valve, it certainly has much to recommend it, especially for fast passenger service.

A gift of $300,000 recently made by Andrew Carnegie, to which $200,000 will be added by the Trustees of Cooper Union, in New York City, will enable that institution to complete the original plan of the founder, Peter Cooper, and open a day school of mechanic arts. The night school has been doing excellent work for years.

IMPROVED ENGINE FRAME CONSTRUCTION.

In an article published in the January issue of this journal, on the subject of Improved Engine Frame Construction and Its Relation to the Proper Application of Driver Brakes, we inadvertently gave a wrong impression as to the position of The American Brake Co. in connection with this subject. Our article might lead one to believe that others had anticipated The American Brake Co. in improvements and inventions of this character. We are, therefore, pleased to state that as far back as May, 1892, The American Brake Co. designed and patented improvements in engine frame construction with the special view of facilitating the application of the best form of driver brakes.

It is gratifying to note that following the publication of our article in the January number a great deal of interest seems to be manifested in the importance of this question, and we only trust that those who have not already read and considered the article will give early attention to the subject.



Passenger Locomotive—Chicago & Alton Railroad.

Capacity of Tender 6,000 Gallons Water and 12 Tons Coal.

H. MONKHOUSE, *Superintendent of Machinery.* BROOKS LOCOMOTIVE WORKS, *Builders.*

EIGHT-WHEEL PASSENGER LOCOMOTIVES, CHICAGO & ALTON R. R.

The new day trains on the Chicago & Alton between Chicago and St. Louis, are new throughout and are hauled by eight-wheel simple engines with piston valves, recently built by the Brooks Locomotive Works. These locomotives are handsome, and where it was possible the outline of the cab roof and cab windows were made to appear in keeping with the new cars, for which this train is famous. The engines are painted the standard Pullman color, like the cars.

There are no unusual features in the engine design, the engine is not large or exceptionally powerful, but the provisions for long continuous running in the size and capacity of the tender is noteworthy. The capacity is 6,000 gallons of water and 12 tons of coal, which is believed to be the largest ever used in passenger service. A small turbine driven dynamo is mounted upon the boiler for electric lights placed along the running board and under the boiler as well as for the headlight. The chief dimensions and characteristics of the engines appear in the following table:

Fuel	Soft coal
Total weight in working order	139,000 lbs.
Weight on drivers	90,500 lbs.
Cylinders	19 x 26 in.
Heating surface tubes	2,000 sq. ft.
Heating surface, firebox	177 sq. ft.
Heating surface, total	2,177 sq. ft.
Grate area	31.8 sq. ft.
Driving wheels, diameter	73 in.
Wheel base, total, of engine	24 ft. 10 in.
Wheel base, driving	8 ft. 9 in.
Wheel base, total, engine and tender	53 ft. 2½ in.
Length over all, engine	38 ft. 7⅜ in.
Length over all, total, engine and tender	64 ft. 3⅜ in.
Height, center of boiler above rails	8 ft. 11½ in.
Height of stack above rails	15 ft. 1 in.
Truck wheels, diameter	36 in.
Journals, driving axle, size	9 by 12 in., with enlarged wheel fits
Journals, truck axle	6 by 12 in.
Main crank pin, size	6 by 6 in.
Main coupling pin, size	4½ by 4 in.
Main pin, diameter wheel fit	6⅛ in.
Piston rod, diameter	3½ in., with enlarged ends
Main rod, length center to center	105 in.
Steam ports, length	21½ in.
Steam ports, width	2 in.
Exhaust ports, least area	50 sq. in.
Bridge, width	3¼ in.
Valves, kind of	10-in. improved piston
Valves, greatest travel	6¼ in.
Valves, steam lap (inside)	1⅛ in.
Valves, exhaust lap or clearance (outside)	Line and line
Lead in full gear	None
Boiler, working steam pressure	210 lbs.
Boiler, material in barrel	Steel
Boiler, thickness of material in shell	11/16, ¾, ⅝ and 9/16 in.
Boiler, thickness of tube sheet	¾ in.
Boiler, diameter of barrel, front	66⅛ in.
Boiler, diameter of barrel at throat	75¾ in.
Boiler, diameter at back head	66⅛ in.
Seams, kind of horizontal	Sextuple
Seams, kind of circumferential	Double
Crown sheet, stayed with	Radial stays
Dome, diameter	30 in.
Firebox, length	114 in.
Firebox, width	41 in.
Firebox, depth, front	79 in.
Firebox, depth, back	65 in.
Firebox, material	Steel
Firebox, thickness of sheets	Crown, ⅜ in; tube, ⅝ in.; side and back, ⅜ in.
Firebox, brick arch	Self-supporting
Firebox, mud ring, width	Back, 3½ in.; sides, 4 in.; front, 4 in.
Firebox, water space at top	Back, 4½ in.; sides, 5 in.; front, 4 in.
Grates, kind of	Cast iron rocking
Tubes, number	306
Tubes, material	Charcoal iron
Tubes, outside diameter	2 in.
Tubes, thickness	No. 12 B. W. G.
Tubes, length over tube sheets	12 ft. 7⅜ in.
Smokebox, diameter outside	69 in.
Smokebox, length from flue sheet	60 in.
Exhaust nozzle	Single
Exhaust nozzle	Permanent
Exhaust nozzle, diameter	4⅞, 5 and 5⅛ in.
Exhaust nozzle, distance of tip above center of boiler	1 in.
Netting	Wire
Netting, size of mesh	2½ by 2½ in.
Stack	Steel taper
Stack, least diameter	13 in.
Stack, greatest diameter	14⅞ in.
Stack, height above smokebox	39 in.

Tender.

Type	Eight-wheel, steel frame
Weight, loaded	120,000 lbs.
Capacity, water	6,000 gals.
Capacity, coal	12 tons
Tank, type	Slope top
Tank, material	Steel
Tank, thickness of sheets	¼ in.
Type of under frame	13-in. steel channel
Type of truck	B. L. W. 100,000 lbs.
Type springs	Triple elliptic
Diameter of wheels	36 in
Diameter and length of journals	5 by 9 in.
Distance between centers of journals	66 in.
Diameter of wheel fit on axle	6⅜ in.
Diameter of center of axle	5⅝ in.
Length of tender over bumper beams	23 ft. 8½ in.
Length of tank	22 ft. ½ in.
Width of tank	9 ft. 8 in.
Height of tank, not including collar	63 in.
Type of draw gear	M. C. B. Janney

EXHAUST AND DRAFT ARRANGEMENTS IN LOCOMOTIVES.

A Review Covering Ten Years.

Mr. C. H. Quereau, Assistant Superintendent of Motive Power, Denver & Rio Grande Railroad, who was selected as Reporter to the International Railway Congress upon the subject of Exhaust and Draft Appliances in Locomotives, has made an admirable review of the progress of the past 10 years and also presents suggestions and conclusions. The complete report is to be found in the Bulletin of the International Railway Congress for December, 1899. A brief synopsis is attempted here.

The conclusions cover American practice and were derived from that of roads having 15,000 of the 36,000 locomotives in use in this country.

In exhaust pipes the tendency is decidedly toward the sin-

gle nozzles, this having been adopted upon two-thirds of the equipment, and is displacing the double pipe. There is a tendency toward reducing the length of the pipe notwithstanding a large average increase in the diameter of smokeboxes in the 10 years. Twenty out of 33 roads in the record have shortened their exhaust pipes in this time. The general adoption of this change would indicate that it was beneficial. The exhaust tip recommended by the Master Mechanics' Association had been adopted by 60 per cent. of the roads, which is presumptive evidence that it is the most efficient form. The reporter made special efforts to ascertain the opinion in regard to the use of bridges or bars in the exhaust tip and found the practice universally condemned, except as a temporary expedient.

Smoke stacks have been reduced in diameter on one-quarter of the roads, the size of the cylinders remaining the same. The cast-iron smoke stack is the favorite with 80 per cent. of the roads and is growing in favor. The diamond stack is standard on but one railroad system, and it is significant that two roads formerly part of that system have discarded the diamond stack upon separating from that system. From these facts it seems reasonable to infer that the diamond stack is inferior in efficiency to the straight or taper form. Mr. Quereau finds that there are no definite rules for varying the stack dimensions for different sizes of cylinders. He believes that the rule given by the Master Mechanics' Association Committee concerning the relation between the stack and the exhaust tip has had considerable influence. Seventeen roads have used variable exhaust tips, and with unfavorable results. The principle is good but they require too much care to keep them in good working order.

The use of draft pipes with extension front ends has increased considerably during the past few years. They increase the draft effect and increase the efficiency of the exhaust by permitting an increase in the size of the tip, which reduces the back pressure. Draft pipes have been at a disadvantage on account of defective fastenings, which have, in many cases, worked loose and caused delay on the road. This, however, is not the fault of the device, but of its attachment.

The original purpose for which the extended front end was designed was to serve as a receptacle for the cinders, but it is a failure in this respect. The fact that 16 out of 25 roads reporting have shortened their extension an average of 17 inches in the past 10 years shows quite conclusively that experience has demonstrated that it does not accomplish the end for which it was designed, or that the gain in draft by shortening is more important than the original purpose. The reporter believes it to be probable that with the extended front end a design may be developed which will leave out the baffle plates and depend entirely on draft pipes for the distribution of the draft, and that such a design would be more efficient than those which depend on the baffle plate.

Mr. Quereau made a study of the von Borries-Troske tests at Hanover, in connection with his paper. (These tests were translated in full in our volume LXX of 1896.) Giving due consideration to the eminence of the experimenters, he observes that as they did not use an actual locomotive, but an improvised piece of apparatus to represent the conditions of the front end of a locomotive, without having even a representation of a stack, their results cannot be considered as representing the conditions of practice. The stack has an important influence on the draft effect and so also does the back pressure, which, in the German tests, was assumed to be constant. Furthermore, the German tests considered only the vacuum produced without taking into consideration the fact that it is produced by back pressure. Mr. Quereau shows clearly that the efficiency and not the vacuum is the important factor. The Master Mechanics' Association tests of 1896 were given the preference in the opinion of the reporter because they were carried out on a locomotive with a stack in place and with means for recording the back pressure and of obtaining the measure of efficiency of the exhaust. This ground is apparently well taken, the preference for the Master Mechanics' findings will no doubt be assailed, but the defence appears to be strong. Mr. Quereau recommends that where the conclusions of the Master Mechanics' Committee and those drawn from the Hanover tests do not agree, the Master Mechanics' conclusions should prevail. The chief differences are with reference to the shape of the exhaust tips, the effect of a bridge in the exhaust tip, the shape of the exhaust jet and the height of the tip with reference to the stack. It is clear that in all of these the actual locomotive conditions are absolutely required for intelligent opinion. No one, however, has assailed the German tests before, and the result, we should say, will be to advance the locomotive testing plant as a piece of test apparatus.

CENTER OF GRAVITY OF A 108-TON LOCOMOTIVE.

A method of ascertaining the height above the rail of the center of gravity of a locomotive devised by Mr. G. R. Henderson was illustrated and described in a recent issue of this journal. Through the courtesy of Mr. Reuben Wells, Superintendent of the Rogers Locomotive Company, we have received a description of another method which was applied to the very heavy consolidation locomotive built by that company for the Illinois Central and illustrated elsewhere in this issue.

This operation was carried out on this engine as a whole and in working order by suspending it on the upper surfaces of two 3-inch steel pins or pivots; the one at the front being located 6 inches in front of the cylinder saddle, and the back one 6 inches back of the back end of the boiler, and both the same distance above the rails and on the vertical center line of the engine. The engine when suspended was complete with all its parts in place and boiler filled with cold water to the second gauge, the drivers and truck wheels all clearing the rails about 2 inches. The engine was as near as practicable in the same condition and of the same weight as it would be in working order. The steel suspension pins were supported at both ends and the bearing surface resting on them was horizontal so as to reduce friction at the bearing point to a minimum. On trial, the bearing points as first located proved to be considerably too high. They were lowered and tested again several times until the engine balanced on the pivots. Screws were used at the ends of the bumper for testing, and to keep the "roll" to either side within limits when the pivots had been lowered to the point of the center of gravity. At that point a lift of about 300 pounds under the end of the bumper was sufficient to cause the engine to turn in the opposite direction to the extent that the bumper at that end was about 8 inches higher than the opposite end. On removing the lifting force the engine would not, of itself, return more than half way back to the vertical position but required a lift of about 100 pounds at the low side to bring it vertical enough to overcome the pivot friction, but when vertical and free, it would remain so. It required about 100 pounds, however, to start it to turn in either direction.

The tests show that the point of suspension was probably as near the actual center of gravity of the engine as it was practicable to locate it. After the adjustments were all made and the center of gravity point found measurements showed the bearing point on top of the steel pin at each end of the engine on which it rested to be 50½ inches above the top of the rails when the drivers are resting on the track. That point is 3¾ inches above the top of the main frames and is indicated in Figure 3 of the description of the engine in this issue.

Assuming the bearing points of the drivers on the rails to be 56 inches apart, then the base on which the engine runs is 1.10 times as wide as the distance its center of gravity is in height above them. Without positive knowledge to the contrary, most persons judging from appearances only would conclude that the center of gravity of a locomotive like this must be considerably above the point given, yet, the tests show conclusively that it is not.

If the center of gravity of a locomotive like this is 10 per cent. less in height than the width of the base on which it is carried, it is probable that the center of gravity could be carried still slightly higher without any detrimental results of consequence as regards the movement of the locomotive along the track.

ECONOMICAL OPERATION OF LOCOMOTIVES.

Pooling, or the "first in, first out" system, is generally accepted as a means for saving large sums in locomotive operation. The advantages are summed up in a recent paper by Mr. M. E. Wells before the Western Railway Club, in an argument which may be summarized as follows:

It enables men to rest while the engines are in use, they are not laid off while the engines are in the shop, the work is better divided up among the men, it makes it possible to do the work with 37 engines that formerly required 52 (in the case cited), which means a saving of $150,000 in the machinery investment; the locomotives may be used almost continuously, the improved methods of inspection result in fewer engine failures on the road, and the greatest possible mileage is made between shoppings.

In the pooling system the question of inspection for defects and loose parts is a most important one. It is equally important whatever system is used, but this discussion brings out the possibility of securing better inspection by providing special round house inspectors for the work. The engineers are not relieved from the duty of looking over their engines before and after runs, but the fact that the special inspectors are never overworked, as are the engineers, by extremely long hours and difficult runs is an important safeguard which has been found effective in preventing break-downs on the road.

Pooling is no longer an experiment. Mr. G. W. Rhodes said that his attention was first drawn to it in 1877. Some objections are made to it on account of difficulties in keeping coal and oil records and it has been criticised because men are supposed to be able to get better results when they always use the same engine. These were given due weight in the discussion and the fact that the details rather than the plan itself concerned the speakers most would seem to indicate that the idea of pooling had gained friends since the subject was before this club in 1896.

Mr. Rhodes cited a case to show that the subject has not received the attention it deserves, as follows:

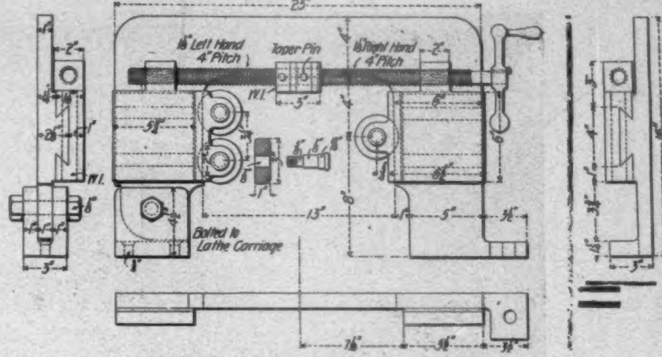
"This spring we had four engines on a certain division, two through passenger trains west and two through passenger trains east. These four engines were worth $10,000 a piece—that is, $40,000. It was found that the run for the round trip was 339 miles, and that the engines could be turned around and brought back to the starting point daily, and by doing so, we would cut the money invested in locomotives in half. Instead of having $40,000 invested in engines we had $20,000. Such economy is wonderful, where it is carried out to great extent. Those two engines now on that run make 339 miles a day, or 10,170 miles a month. What is going to make this method of handling these trains successful? It depends entirely upon the capacity of the engines to make 339 miles a day without a failure."

ROLLER ATTACHMENT FOR AXLE LATHES.

Allegheny Shops, Pennsylvania Company.

The increasing extent of the use of burnishers in the form of rollers for finishing the surface of journals, crank pins and piston rods was commented upon in our May issue of last year, page 156, and through the courtesy of Mr. W. F. Beardsley, Master Mechanic of the Pennsylvania Co., at Allegheny, Pa., we are enabled to illustrate still another burnisher for work of this character.

This device was designed at the Allegheny shops and reference to the drawing shows that it consists of a yoke-shaped frame secured to the carriage of the lathe and supporting three rollers, two at the left and one at the right, which are operated by a right and left hand screw to force the rollers against the axle. The stresses are therefore self contained in the attachment and the thrust due to rolling is not transmitted to the centers, which support the axle. This fixture is hinged on the rear side of the carriage and may be turned out of the way



Roller Attachment for Lathes.

when not in use. It is usually left in position, as its size and form are such that it will clear the tail stock of the lathe.

The rolling is done while the finishing cut is being taken over the wheel fit, whereby time is saved in completing the axle and no time is lost through the application of the burnisher. This arrangement effectually prevents springing the work due to the pressure of the rollers and it entirely relieves the centers from additional stress. It is evident that this feature of the design renders it specially well adapted to work on piston rods and valve stems, in which case the thrust of a single roller would be a serious matter. This attachment is now in use on an axle lathe in the Allegheny shops and is reported to be doing excellent work.

GOOD AMERICAN PRACTICE IN CRANK PINS AND AXLES.

An example of good practice in the design of locomotive details is the comparison, as shown in the "Railroad Gazette," of the axles and crank pins of the main driving wheels of a Lake Shore and Michigan Southern ten-wheeler and a North Eastern (English) ten-wheeler. Mr. L. R. Pomeroy in the June issue of the "American Engineer and Railroad Journal," for 1898, gives two excellent formulas, one for figuring the crank pins and the other for driving axles, from which the following results are derived:

	Lake Shore & Michigan 10-wheeler.	North Eastern 10-wheeler.
Cylinders, in. by in.	20 by 28	20 by 26
Boiler pressure, lbs.	210	200
Maximum fiber stress in main crank pins, lbs. per sq. in.	13,225	20,170
Maximum fiber stress in main driving axle, lbs. per sq. in.	21,700	23,740

In the case of both drivers the crank pins and axles have enlarged wheel fits. The diameter of the Lake Shore axle is 9 inches, with a wheel fit of 9½ inches, while that of the North Eastern is only 7¾ inches, with a wheel fit of 9 inches. The weight on the main drivers of the Lake Shore engine is 44,000 pounds, making a difference of only 1,000 pounds in excess of the North Eastern and has 50 per cent. greater area of journals. The crank pin is also of a larger diameter than that of the North Eastern. Mr. Pomeroy has found from his careful study of the breakages of crank pins and axles a maximum safe fiber stress for iron and steel axles of about 18,000 and 21,000 pounds respectively, and for iron and steel crank pins, 12,000 and 15,000 pounds respectively. From the table it will be seen that the fiber stress in the Lake Shore axles and crank pin are very close to the best practice while those of the English engine are high.

Mr. Thomas Tait, General Manager of the Canadian Pacific, has no misgivings concerning the recent adoption of yellow as a color for distant signal lights on that system. He recently wrote about this important step as follows: "We have adopted the Nels yellow (which I think should be called the Baird yellow) as our standard color for caution, and all of our interlocking plants are now equipped with it and it is giving great satisfaction." Mr. John C. Baird, who was the originator of this glass, informs us that the Canadian Pacific will use green for "all clear" or "proceed" signal, and that a new classification color for locomotive lamps will be adopted.

A Street Transformed into a Shop by an Electric Crane, Baldwin Locomotive Works. Crane Built by Wm. Sellers & Co.

A VALUABLE CRANE.—BALDWIN LOCOMOTIVE WORKS.

The devices and equipment for handling materials generally reflects the real prosperity of manufacturing establishments, and particularly those requiring the movement of heavy pieces. The electric traveling crane has had a revolutionary effect upon shop design and arrangement, and in the development of rapid work for which this country has become famous. A good example of what cranes will do may be seen at the Baldwin Locomotive Works in Philadelphia. Cranes, adapted for the special requirements of each department are contributing in a very important way to the enormous productive capacity of this plant, the works as now equipped being an excellent place to study the problem of moving heavy weights and using space advantageously.

The cranes are the product of Wm. Sellers & Co., and by means of the photograph a unique example is shown of how a crane will render an awkward and unused space available for shop purposes. This crane has a span of 37 feet, a lift of 26 feet and a lifting capacity of 25 tons. It is operated by three motors and is run out of doors, the cage being enclosed and the crane roofed over with corrugated iron. This crane spans the walls of the shop buildings on both sides of Buttonwood Street from Broad to Fifteenth Streets, a distance of about 350 feet. The crane is a very efficient one and capable of handling all of the work required. It renders this entire area available for wheel work and storage for wheels, boilers and other parts for which there is not room in the shops. It saves the erection of another building and the condition shown in the photograph would be entirely impossible without it. The picture incidentally gives an idea of the present crowded condition of the Baldwin works.

THE SLOT IN THE M. C. B. KNUCKLE.

A Serious Weakness.

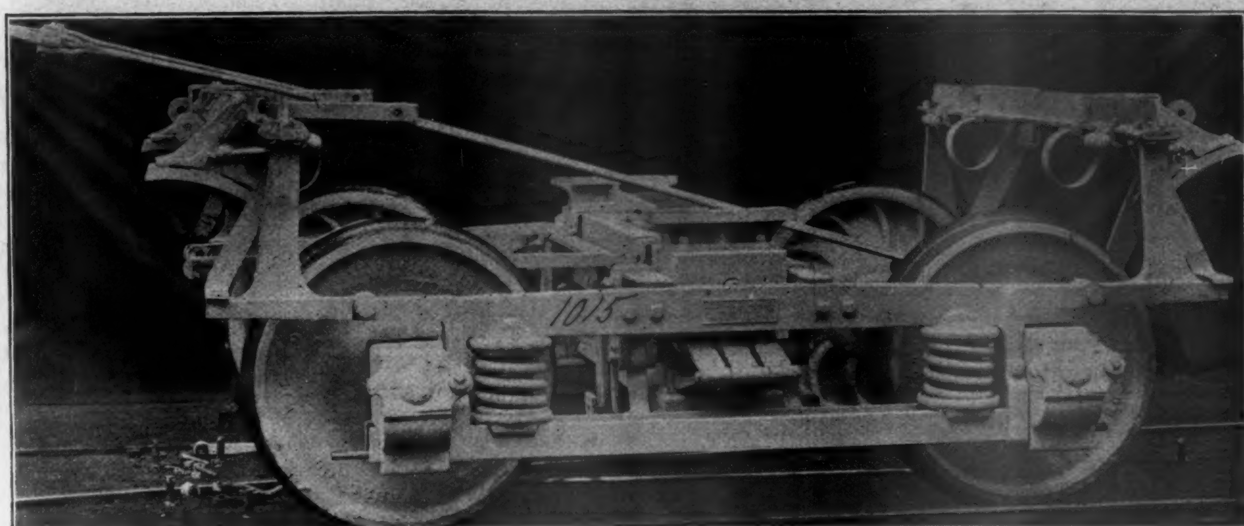
The fact has long been known that the M. C. B. knuckle is weakened by the slot and pin hole provided for the purpose of coupling with links when necessary, but there are few who will not be surprised by the figures given by Mr. J. W. Luttrell, Master Mechanic of the Illinois Central, before the Western Railroad Club last month.

Out of 200 broken knuckles taken at random from the scrap pile, 60 per cent. had broken through the pin hole and 11 per cent. through the link slot, making 71 per cent. due to these two weaknesses.

Statistics showed that in the operation of 31,997 cars with M. C. B. couplers during 12 months, 4,096, or 6.4 per cent., failed from the cause in question. This proportion of the 2,600,000 knuckles in use in the United States means the failure of 166,400 knuckles annually, and at the average price of $1.65 the loss amounts to $274,560 per year.

The advisability of closing the slot and the pin hole as soon as possible is fully realized, and it may be possible to do this at the expiration of the time set for compliance with the safety appliance law. Wearing surface as well as strength is involved. Mr. Luttrell showed that the present wearing surface

New Brill Truck.



New Brill Truck Showing Swinging Jaws.

was about 17½ square inches, and this would be increased 28 per cent., or to 22½ square inches, by closing the slot. This will increase the weight about 9½ pounds and the cost about 38 cents each, but the net saving to the roads in the United States would be $248,872 per year.

The only objection raised to the closing of the slot after the safety appliance act has been complied with, is the frequent necessity for pulling cars out of curved sidings and other curved pieces of track upon which the M. C. B. coupler will not couple. The McConway & Torley Company have put knuckles into service with the slot closed, and in order to permit of pulling cars out of such places a lug is cast upon the top of the knuckle. This serves for the attachment of a switch rope or chain, and an equally simple device is a strong ring placed permanently upon each corner of each car for the attachment of a chain or rope.

The size of the slot has never been established as a standard and it varies, with different knuckles, from 1⅞ to 2¼ inches. It is obvious that a material increase in strength might be had by reducing this width to 1½ inches. This was done experimentally by the Burlington about a year ago, with very satisfactory results. The largest link is 1¼ inches thick and there appears to be no good reason for making the slot more than 1½ inches wide.

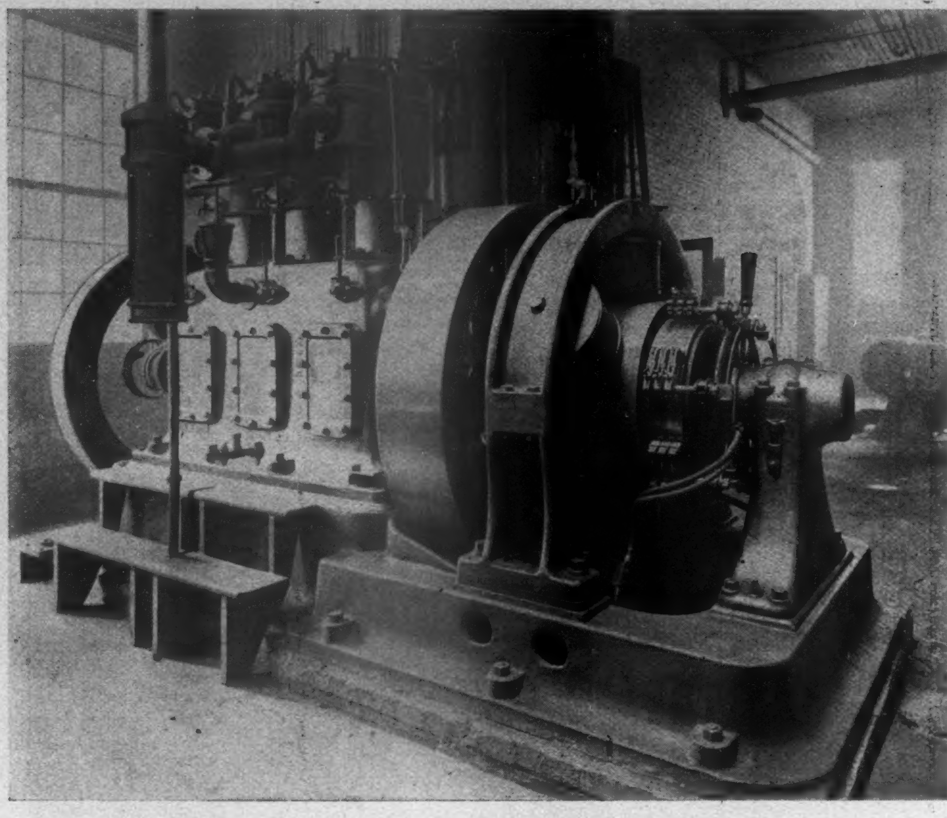
A NEW TRUCK BY THE J. G. BRILL CO.

This truck is an improvement upon the type brought out by the J. G. Brill Co. several years ago, and illustrated on page 89 of our issue of March, 1898. It was designed with special reference to the equipment of electric motor cars for the attachment of motors, but is also well adapted to use under passenger cars of any kind. It embodies a large amount of experience and is the result of consistent efforts toward improvement, a motive worthy of most hearty encouragement.

The general practice in passenger truck construction is unaccountably crude. None are so severe as railroad men in their condemnation of complication in new devices, yet they have permitted the provisions for increased stresses in passenger trucks to take the form of adding to the number of parts until a "standard truck"—particularly when it has three axles—is an astonishing mixture of wood and iron with apparently no thought of the immense number of individual pieces, a practice of which no parallel in railroad practice can at this time be recalled.

A glance at this new truck brings the impression of simplicity. It is evident that easy riding and a low center of gravity have also been considered. The features of this design are the cast steel frames, the projection of the equalizers through the bottom portions of the boxes and the location of the equalizer springs close to the boxes. The truck is made very low by this arrangement of the equalizers and this location of the coil springs gives an unusually long spring base and consequent stability. The springs are brought close up to the faces of the inner pedestal jaws and the spring centers are about 10 inches from the centers of the axles, whereas in usual construction this dimension is from 20 to 22 inches. This construction also aims to prevent the tilt of the truck frames upon the application of the brakes, the equalizers being passed through the boxes and held by saddles around the pedestals. For convenience in removing the wheels the outer pedestal jaws are hinged so that it is not necessary to raise the truck.

A number of these trucks are in service, most of them being in Kansas City, Mo.



125-H. P. Westinghouse Gas Engine, Direct Connected.
In the Power House of the H. K. Porter Co., Pittsburgh.

A SUCCESSFUL GAS-ENGINE POWER PLANT.

By Burcham Harding.

One of the most successful power plants is found at the locomotive works of the H. K. Porter Company, Pittsburg, Pa. Sharing in the prosperity which has been general with the manufacturers of Pennsylvania, the H. K. Porter Company found it necessary to make considerable additions to their works, and the problem presented itself how best to provide lighting and power. It was decided to abolish separate steam engines and to provide an electrical drive. At first this was done tentatively, by the installation of a 90-horse power Westinghouse three-cylinder gas engine, direct connected to a 60-kilowatt direct-current generator. The successful operation of this unit for more than a year led to the further installation of a 125-horse-power Westinghouse gas engine, direct connected to a larger generator.

These two units are installed in a small extension of the engine room, occupying very little space. Electric current is supplied for 32 arc and 400 incandescent lamps, mainly in the old works, to which additions will be made for the newer extensions. In the machine shop are two 25-ton overhead travelling cranes, operated electrically, and one crane of 15 tons in the foundry. Motors for driving blowers and overhead shafting are now in course of erection, and it is intended that the whole of the works shall be operated electrically. The fuel used for the engines is natural gas, costing 20 cents per 1,000 cubic feet. The gas bill amounts to so small an item as to be virtually a negligible sum. The engineer in charge reports that these gas engines have given the very highest satisfaction, not only from the point of economy in fuel consumption, but also from that of steadiness and regularity. Water for cooling the cylinder jackets is obtained from the city mains, the consumption being about four gallons per brake horse power per hour. The circulation is accomplished automatically by the heat absorbed in the jackets, no pump or other mechanism being required.

The starting of one of these engines is a simple and easy matter, which is accomplished by the use of compressed air. The engine is given a couple of turns by the air cylinder, and when a charge of gas and air has been drawn in, compressed and exploded, the task is accomplished. The air supply is furnished by a small Westinghouse compressor, the air being stored in iron tanks, tested under a pressure of 250 pounds per square inch. The tanks are supplied with a pressure gauge and a safety valve to guard against overcharging, and they are shipped charged to 160 pounds pressure for starting the engine the first time. When the plant is once in operation the compressor is run for a few minutes each day by a belt from a convenient pulley, either on the engine itself or on the line shaft, maintaining the supply in readiness for starting at any time. The entire operation is strictly automatic, requiring no particular mechanical dexterity on the part of the attendant, and consuming less time than it takes to describe it.

INSTRUCTION IN CARE OF JOURNAL BOXES.

New York Central & Hudson River R. R.

In the multitude of details requiring attention on large railroad systems, few are of greater importance than the proper care of journal boxes of cars and locomotives. Indifference as to the importance of this, or a slight lack of knowledge of the actual necessities of properly maintaining the packing, frequently result in numerous cases of hot journals. A good idea in connection with the prevention of hot journal boxes has been developed on the New York Central, from a suggestion made by Mr. H. C. McCarty of the Galena Oil Company.

A full sized model of an M. C. B. journal box, made of galvanized iron and provided with a sheet metal representation of a journal is furnished to the car inspectors at all points where cars are inspected and journal boxes are cared for. This model has lights of glass let into the side in such a way as to give a clear view of the interior of the box, which may be packed and oiled after the manner of the car journal boxes. The idea is to use this in instructing new men in their duties, and also in securing uniformity in the work of the men in all parts of the system. Instruction will be given in the proper method of placing the packing, in oiling it and in the use of the packing hook to keep it loosened up in good condition for properly lubricating the journal. Many inspectors do not give proper attention to the loosening of the packing with the hook, and this is probably as important as the frequent addition of oil to the box. It is customary to pack the boxes up to about the center of the journal, and by aid of the glass windows the exact condition of the waste may be seen at a glance and it may also be ascertained whether the methods in use insure the proper packing of the boxes at the back ends. One of the chief causes of trouble is failure to keep the packing in contact with the journals which results from the

endwise motion. In this way the journal may become dry and an opening at the wheel end may be made which will admit dust from the outside, and at the same time the condition at the other end may be good.

In using the model among men now in service the glass will be covered by slides while the box is packed, and the work may then be inspected by uncovering the windows and the proper instructions given. Its purpose is to insure uniformly good work among the old hands as well as the new. It is the intention of the Galena Oil Company to extend the idea among other roads. Mr. Waitt, Superintendent of Motive Power of the New York Central, has given a great deal of attention to the prevention of hot boxes, and this is in line with other simple and effective remedies, the most important of which is the influence of a carefully kept record of delays which are chargable to the care of journal boxes.

Mr. Waitt appreciates the importance of instructing the men having charge of lubrication so that they will do their work uniformly. He recently issued an elaborate circular of instructions for guidance all over the system and the idea should be taken up generally. The following is quoted from the portion relating to the method of packing and the preparation of the waste:

In packing boxes, the first portion of waste applied is to be wrung moderately dry, and it to be packed moderately tight at the rear end of the box, so as to make a guard for the purpose of not only retaining the oil, but excluding the dust as well. Care is to be taken to keep the waste at the side of the box down below the bottom of the journal bearing about an inch, and also to have that portion of the waste in the front end of the box separate and distinct from that which extends from the front end of the journal to the back of the box. This will avoid derangement of the packing in the rear of the box. The roll of packing which is placed in the front of the box is not to extend above the opening in the front.

At terminals or yards where journal boxes require special attention to the packing, the following practice is to be adopted:

A packing knife or spoon of standard style should be used. This packing knife or spoon is to be used to ascertain whether the packing is in the proper place at the back of the box, and to loosen up the waste at the rear and side of the journal. This particular treatment is given to prevent glazing of the packing (which occurs when it is too long in contact with the journal), and, at the same time, to put the packing in the proper place at the rear of the box. It is desirable to give this treatment at intervals of 500 miles run for cars and tenders if possible.

A small quantity of packing is to be removed from the sides of the journal when found not in a good condition, and this replaced by similar quantity of well-soaked packing. No box is ever to have oil applied before the packing is properly loosened up on the sides and back of the box with the packing iron.

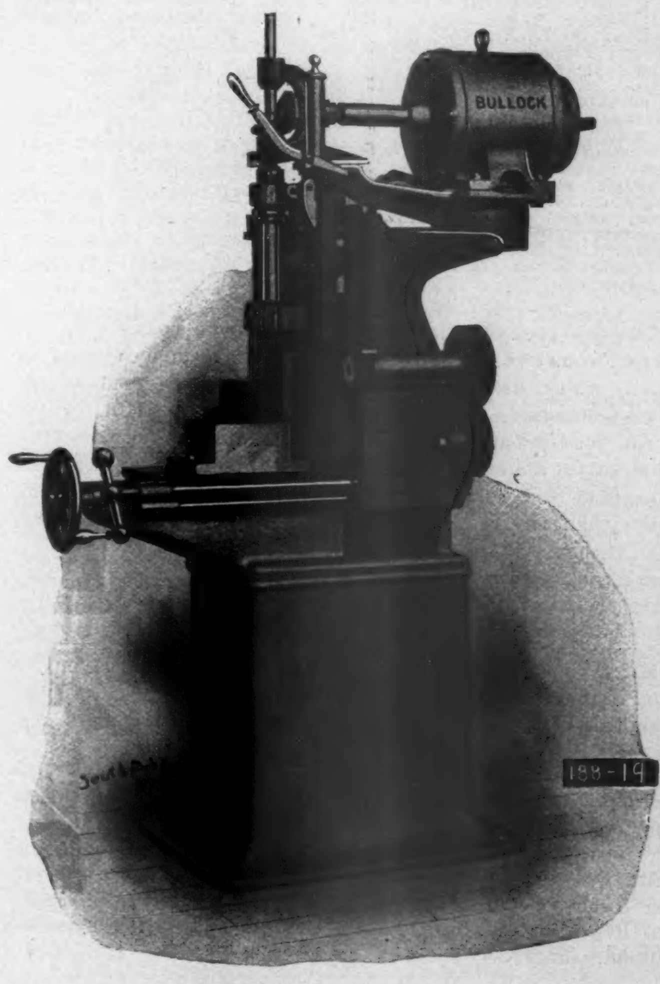
Before applying a bearing to a journal the surface of the bearing is to be examined to insure that it is free from imperfections of any kind that will cause heating. The surface of the bearing is then to be oiled or greased before it is placed on the journal. When applying wheels or axles the journals are to be examined to insure their being free from any imperfections which would cause heating. When wheels or axles are carried in stock, the journals should be protected with a good material suited to protect the surface, without hardening, and one which is not difficult to remove.

When the journal is found heated and there is a good supply of packing in the box, it is evidence of some imperfection of the journal, journal bearing, box, or wedge, and the bearing is to be removed provided the box is heated to such an extent as to require repacking of the box. Boxes which have warmed up slightly will in most cases, by partially replacing with freshly soaked packing, give better results than by entire removal of the packing from the box. When it is necessary and permissible to oil boxes, it should be as short a time before leaving time of the train as possible.

When preparing packing, the dry waste is to be pulled apart in small bunches and any hard particles in it removed. Each bunch is to be loosely formed to facilitate soaking and packing, as in this form boxes can be packed in a more satisfactory manner and with less waste of oil. This loose, dry packing is to be put in soaking cans or tanks provided for that purpose, pressed down moderately tight, then covered with oil and allowed to remain at least forty-eight hours. After being saturated for this length of time the surplus oil is to be drained off, leaving it then in proper condition for use in packing boxes. Standard equipment for saturating and draining packing is to be provided at all points where packing is to be kept for use, unless suitable equivalent equipment is already in use.

DIRECT MOTOR-DRIVEN PROFILER.

The accompanying engraving illustrates a profiling machine driven directly by means of a Bullock motor. This machine is rather a difficult one in which to directly apply an electric motor, as the length of shaft between the motor and spindle is of necessity a varying length, caused by the continuous movement of the carrier. To avoid the use of intermediate belting,



Direct Motor Driven Profiler.

which is generally necessary on machines having a vertical movement of the spindle, the Bullock Electric Manufacturing Company have placed the motor upon a base which is pivoted to the frame of the machine. This allows a vertical movement of the spindle and at the same time the shaft is kept at right angles with it by means of a joint in the spindle. A splined shaft and sleeve connects between motor and spindle, which adjusts itself to the variations in length by the sliding of the shaft within the sleeve.

The motor is fully described in Bulletin No. 2,435, which may be obtained by addressing the Bullock Electric Manufacturing Company, Cincinnati, Ohio.

THE INCREASING WEIGHTS OF LOCOMOTIVES.

The Brooks Locomotive Works have made an interesting comparison of the characteristics of locomotives which they built last year, and in earlier years. This shows the strong tendency toward the use of heavier and more powerful locomotives, and particularly in the comparison of the output of completed locomotives for the years 1891 and 1899, these two years representing the greatest output of these works.

The equivalent weight of locomotives and tenders completed in 1899, if based upon the average weight of those produced in 1891 would be 439 complete locomotives, as against 300 which were actually completed in 1899. The lightest locomotive built during the year was a mogul which with its tender weighed 97,014 pounds, while the heaviest was a 12-wheeler and tender, weighing complete 364,900 pounds. The latter is the huge freight engine for the Illinois Central, with 23 by 30-inch cylinders. (American Engineer, October, 1899, page 315). The comparison referred to has been put into tabular form, as follows:

Brooks Locomotive Works. Completed Locomotives.

	1891.	1899.	Increase.	Average Increase.
Number built	226	300	74	
Weight engines and tenders in working order, lbs.	41,726,350	81,123,600	94½%	
Same expressed in net tons	20,863	40,562	19,699	
Average weight in lbs.	184,629	270,412		85,783 lbs.
Weight, engines only, in working order, lbs.	25,455,100	49,730,400	95 1/3%	
Same in tons	12,728	24,865	12,137	
Average weight, engines only	112,633	165,768		53,135 lbs.
Total weight engines and tenders empty, showing amount of material used in lbs.	24,778,410	57,681,300	93¾%	
Same in tons	14,889	28,841	13,952	

The low cost of rail transportation, made possible by the large locomotive, as compared with the cost of movement by canal, which has always been popularly considered as the lowest standard, was clearly put by President Hill, of the Great Northern Ry. In an interview printed in the New York "Journal of Commerce," he said: "Eliminating the terminal charges at New York, the rates by rail from Buffalo are already lower than any canal, small or large, could carry grain for, even if the Erie Canal was deepened to 50 feet."

PERSONALS.

Mr. F. B. Shepley has been appointed Purchasing Agent of the Fitchburg, with office at Boston, in place of Mr. G. J. Fisher, resigned.

Mr. B. Haskell has been appointed Superintendent of Motive Power of the Pere Marquette Railroad Company, with headquarters at Saginaw, Michigan.

Mr. Brown Caldwell has resigned as Secretary of the Peerless Rubber Company, to accept the position of General Eastern Representative of the Sargent Company, with offices at Pittsburg and New York.

It is officially announced that Mr. S. M. Felton, President of the Chicago & Alton, will also assume the duties of Mr. C. H. Chappell, Vice-President and General Manager, who retired from this position on Jan. 1.

Mr. F. H. Greene, Chief Clerk of the Motive Power Department of the Lake Shore & Michigan Southern, has been appointed Purchasing Agent of that road, with headquarters at Cleveland, O., vice Mr. C. B. Couch, resigned.

Mr. F. W. Deibert has resigned as Master Mechanic of the Chicago, Milwaukee & St. Paul, at West Milwaukee and will go with the Baltimore & Ohio as Assistant Superintendent of Motive Power, with headquarters at Newark, Ohio.

Mr. J. O. Pattee has resigned as Superintendent of Motive Power of the Great Northern. His position has been abolished and the position of General Master Mechanic has been created, to which Mr. G. H. Emerson, Master Mechanic at Larimore, N. D., has been appointed.

Mr. W. G. Collins has resigned as General Manager of the Chicago, Milwaukee & St. Paul, to take effect February 1. Mr. Collins entered railway service in 1868 with the Chicago, Milwaukee & St. Paul, but was later on the Northern Pacific and the Canada Southern. He returned to the Milwaukee road in 1873, since which time he has held various responsible positions.

Mr. T. W. Demarest, Master Mechanic of the Pennsylvania shops at Logansport, Ind., has been appointed Superintendent of Motive Power of the Pennsylvania Lines West of Pittsburg, Southwest System, to fill the position made vacant by the resignation of Mr. S. P. Bush, who recently succeeded Mr. J. N. Barr on the Chicago, Milwaukee & St. Paul. Mr. Demarest began his railroad work in the Pennsylvania shops at Indianapolis, and after being appointed General Foreman, he was recently transferred to Logansport as Master Mechanic.

Thomas B. Twombly, formerly General Master Mechanic of the Chicago, Rock Island & Pacific, died at his home in Chicago, October 31, aged seventy-six years. After serving his time as an apprentice in the machine shops of the Cocheco Cotton Mills, at Dover, N. H., he entered the service of the Connecticut River Railroad, as locomotive engineer. In 1859 he was Master Mechanic of the Newburyport & Georgetown, and foreman of the machine shops of the Mississippi & Missouri, in 1867, which position he left to enter the service of the Rock Island System as General Master Mechanic, and remained in this capacity for nearly 24 years. Among several interesting papers concerning Mr. Twombly received from Mr. Geo. F. Wilson, Superintendent of Motive Power of the Rock Island, is a letter of recommendation given Mr. Twombly by President Poole of the Newburyport Railroad in 1857. Mr. Poole stated that he was "a capable, faithful and industrious man." To these qualities he owed his success and advancement.

The death of Charles P. Krauth, Secretary and Treasurer of the McConway & Torley Company, December 27, in Pittsburg, is an unusual loss, for such men are needed and are very rare. He was a man of ability, possessing to an unusual degree the qualifications which make business success, and with his delightful personal attributes he gained a high place in the esteem of those with whom he came in contact, both in business matters and otherwise. He contributed an important part of the success of the firm with which he was connected. Mr. Krauth was born in Winchester, Va., in 1849. After graduating from the University of Pennsylvania he studied mining engineering for eight years at Freiberg, Germany, and on his return to this country entered the service of the Pullman Palace Car Company as District Superintendent. He afterward held a similar position with the Wagner Company, and in 1888 became Secretary of the McConway & Torley Company, and was one of the leaders in building up the extensive interests of this concern.

BOOKS AND PAMPHLETS.

Railroad Curves and Earthwork. By C. Frank Allen, S.B., M. Am. Soc. C. E., Professor of Railroad Engineering in the Massachusetts Institute of Technology. Spon & Chamberlain, New York. Leather, 4 by 6½, pp. 194. Price $2.

This is an admirable book on railroad curves and earthwork. In the variety and number of field problems and in the mathematical statement and solution of these problems, the work is very satisfactory. The frequent use of the convenient versed sine is to be commended. The treatment of compound curves, vertical curves, turnouts, and crossings is good and is an im-

provement over that given in most field books. The chapter on spiral easement curves describes the cubic parabola, a curve which is not very satisfactory for easements of sufficient length to be of value for high speeds. It contains no application to curves in existing track. The chapters devoted to setting stakes for earthwork, to the computation of earthwork and haul, to earthwork tables and diagrams, and to haul and mass diagrams are especially clear and discriminating and altogether form perhaps the best presentation of this subject yet published. The usefulness of this part of the work is lessened by the limited number of tables and diagrams. It is to be hoped that the author will include in the next edition a wider variety of bases and slopes and thus make it a standard treatise on earthwork. The author has seen fit to retain the old definition of degree of curve based always on a full chord of 100 feet. This is to be regretted, since engineers generally use shorter chords for the sharper curves, and the recognition of this use greatly simplifies calculations and tables. Some of the newer field books have based their formulas and tables upon the modern definition. This is not a railroad engineers' field book in the usual sense, since it does not contain trigonometric and other mathematical tables, but as a treatise for students and as a reference book for curve problems and earthwork it is a valuable work and is worthy of a place in the library of the engineer.

Engineering Rules and Instructions of the Northern Pacific Railway. By E. H. McHenry, Chief Engineer. Published by Engineering News Publishing Co, New York, 1899. Price 50 cents.

This little book of 75 pages contains a concise and up-to-date treatment of the subject of the engineering department of a railroad and rules for its government in organization and work. Under "Location" a great deal of valuable matter in regard to traffic, curvature, grades and maintenance is given. The power of locomotives and the effect of grades upon their economy of operation are discussed. Other chapters treat of surveys and construction, track and ballast, bridges and culverts, accounting and supplies. The great importance of the location and original construction of the road upon the cost of operation is better presented in this book than in any work since the appearance of Wellington's work on location. Mr. McHenry has put his ideas into department rules and many will be indebted to him and "Engineering News" for making them available in so convenient a form.

Kinematics of Machinery. By John H. Barr, M.S., M.M.E., Professor of Machine Design, Cornell University. New York: John Wiley & Sons; pp. 247, 8vo, 200 illustrations. Price $2.50.

In this book is presented in condensed form the leading principles and methods which are of most importance in a general course in kinematics. While it is not in any sense a complete treatise on the subject, yet it will be found to contain the essential principles of the science. In its general arrangement Professor Barr has closely followed Stahl & Woods' "Elementary Mechanism," but this has been greatly strengthened by the introduction of much additional matter and applications of such important conceptions as instantaneous centres, velocity diagrams, centroids, axiods, and linkages. The treatment of these subjects follows closely that given by Professor Kennedy in his admirable work on the "Mechanics of Machinery," which adds very much to the value of the book. The treatment of many topics has been necessarily somewhat abridged, but this is an advantage rather than otherwise. This is notably true of that portion relating to toothed gearing which frequently receives attention out of all proportion to its value. The subject of cams is presented in a practical manner, possibly somewhat too briefly, but the reader will have no difficulty in obtaining a good knowledge of this branch of kinematics, if he works out the interesting problems which accompany the text and are designed to illustrate the principles treated. Professor Barr has shown good judgment in selecting his material for this book which can be recommended as a well-arranged, clear and concise treatise on the subject.

The press-work and illustrations are of a high order of merit and add much to the value of the book.

The Use of the Slide Rule. By F. A. Halsey, Associate Editor "American Machinist." Van Nostrand's Science Series. Published by D. Van Nostrand Co., 23 Murray St., New York: 1899. Illustrated. Price, 50 cents.

This is an excellent instruction book on the use of the slide rule. It is elementary and the author's purpose seems to be to enable one who is entirely ignorant of the theory of the instrument to use it intelligently. The explanations are accompanied by engravings showing the various settings, as they are actually made for solving various problems. The book ought to have a wide circulation, and its effect will undoubtedly be to greatly increase the use of the slide rule as a labor saver to the engineer. The work is systematically arranged, and the student is led very gradually into the more difficult problems. His difficulties have been foreseen and provided for, but the work is not obscured by too much of the theory of the subject. The author's style is very clear, concise and satisfactory. The book closes with chapters on special forms of computers involving the principles of the slide rule.

Notes on the Construction of Cranes and Lifting Machinery. By E. C. R. Marks, Asso. Member Inst. C. E., Member I. M. E., etc. New and enlarged edition. D. Van Nostrand Co., 28 Murray St., New York: 1899. Price, $1.50.

This little book describes English practice in hand and power cranes, with their accessories for a variety of purposes. The chapters are: Pulley blocks, crabs and winches, double-purchase crabs, treble-purchase crabs; hand, pillar, whip, foundry, wharf and overhead traveling cranes; steam power hoists, cage and car lifts, locomotive cranes, rope driven cranes, jacks, etc. The closing chapters describe ship derricks and electric cranes, showing methods of attaching motors. It is not the best that may be done with this subject, but it covers quite a large portion of the field of hoisting appliances. Those who are infrequently called upon to design hoisting apparatus will find it useful, and more so than will expert crane designers. It is hardly up-to-date as a treatise because it does not touch upon the important development of elevating and transporting machinery in the United States, which is unique and even revolutionary. The book is good, but it would be much more valuable if it gave a complete treatment of the subject. The engravings are not good.

Problems in Machine Design. By Charles H. Innes, M.A., Engineering Lecturer at the Rutherford College, Newcastle-on-Tyne, England. Second edition. D. Van Nostrand Co., 23 Murray St., New York: 1899. Price, $2.00.

This book was written to supply engineering students with a book on machine design which should carry them a step further than the mere formulae for application to their problems. The author works out examples to explain the use of the formulae; he does not write for those who are content to copy the designs of others. The work is purposely incomplete because the author intends to write again on the subject of the design of complete machines; in this case he treats the elements only. There are many books on machine design. The reviewer believes that the best works on machine design are those which offer the theoretical treatment with derivation of formulae and also present the results of practice. There are many stresses in machinery that are misunderstood, and the best formulae are those which are made to fit the practice which is found to be successful. This work presents chapters on graphic and other methods of finding longitudinal stresses in framed structures, bending moments, tensile, shearing and compressive stresses, and then takes up the practice recommended by such bodies as the Board of Trade. The piston rod is treated as a column, and formulae obtained; then the practical side is brought in by a table representing marine stationary and locomotive practice. Shafting is treated in a similar manner, the evident tendency being toward marine practice. A chapter on expansion valve gears treats of several types and includes a few fly-wheel governors. A chapter gives the most recent methods of balancing multiple expansion marine engines, and the book closes with a study of the distribution of work in the compound engine. A large amount of attention is given to cranks, shafts, both hollow and solid, and riveted joints. We find a number of valuable tables which we have not seen in any other work on this subject.

The "Blacksmith and Wheelwright" appears as a souvenir number in its January issue, this being the 20th anniversary of its first publication. It is the reliable paper for the blacksmith and wheelwright trades and has always enjoyed a high position, won by reliability and merit.

The Railroad Officials' Diary for 1900. Issued by the "Railroad Car Journal," New York. This is an attractive and convenient diary with a whole 6 by 9 inch page for each day of the year. It is bound in flexible leather. The fly leaves at the front and back give a list of railroad technical associations with the dates of meetings, statistics of railroads and a list of the names of leased roads. Copies will be sent to railroad officers on application.

A brochure has just been issued by the W. Dewees Wood Co., McKeesport, Pa., which is one of the best productions of the kind that we have seen. It combines an account of the inception and growth of this concern, and the method of manufacture of its product in such an artistic and tasteful way as to compel the attention of one into whose hands it falls. It is the work of an adept in plan and execution. The text and engravings trace the history of the enterprise of this successful concern and follow the process of manufacture from the preparation of the charcoal and the selection of the iron, to the finished plates of patent, planished or color smooth black sheet iron, for which these works are famous. The pamphlet contains tables of the iron and steel plate and sheet gauges.

From the literary point of view, the leading feature of the January magazine number of "The Outlook" is the first installment of Mr. Hamilton W. Mabie's "William Shakespeare: Poet, Dramatist, and Man." In this series of articles, which will extend throughout the year in the monthly magazine numbers, Mr. Mabie will offer, not a formal biography, but an attempt to realize the poet and dramatist as a great Englishman, to approach him through the atmosphere of his own age, to set him distinctly in his own time, to bring about him his brilliant contemporaries, and to exhibit him as a typical man in a great epoch. The first installment deals with "The Forerunners of Shakespeare," and is illustrated with portraits, curious representations of the ancient street pageants, miracle plays, and dumb shows; for the entire series there has been gathered a great mass of illustrative material of value and beauty.

Brooks Locomotive Works Catalogue.—This volume of 336 pages is a very creditable publication in every respect. It brings together in a convenient and comprehensive form a large number of locomotives of different types built by them, giving the leading dimensions and capacities. These are illustrated by excellent full-page half-tone engravings and opposite each is the corresponding table of information. Each description has a code word. The book includes the Brooks standard specifications, a history and description of the works, a description of the Brooks design of piston valves, and of the Brooks system of construction of two and four-cylinder compound locomotives. The volume closes with convenient tables of tractive power, piston speed, mean available pressures, revolutions of driving wheels, train resistance and a cipher code. These tables are of wide range and they will cause a great demand for the book aside from its value as a record of construction and as a basis for ordering. The paper, printing and binding are excellent throughout.

EQUIPMENT AND MANUFACTURING NOTES.

The Magnolia Metal Co. have opened a branch office in room 421 Austell Building, Atlanta, Ga. This step is made necessary by increasing business. They are also about to open offices in St. Louis, San Francisco and Philadelphia.

Simplex bolsters have been specified for the construction of 200 box cars building for the Louisville, Evansville & St. Louis, at the works of the Barney & Smith Car Company, Dayton, Ohio.

The Powers Regulator Co. are entering the railroad field to provide apparatus for regulating the temperature of steam-heated passenger cars. They have secured the services of Mr. Charles F. Pierce, who is well known in connection with the Monarch Brake Beam Co. He will have offices in New York and Chicago and will take charge of the railroad department.

The Cling-Surface Mfg. Co., Buffalo, N. Y., have established a New York City branch office at 205 Postal Building, 253 Broadway, to facilitate handling their increasing business. They have also issued a booklet of pictures of belts running slack after using "Cling-Surface," which, from the point of view of past tight belt teaching, is sensational. The demand for "Cling-Surface" is increasing among the railroads and a number of repeated orders have been placed.

The Star Brass Manufacturing Co.'s new catalogue for 1900 contains illustrated descriptions of a very large line of railroad and steam plant specialties which are far too numerous to be even mentioned in detail. The most important are non-corrosive pressure and vacuum gauges, revolution counters, engine registers, locomotive and marine clocks, steam engine indicators, whistles, water gauges, gauge cocks, Siebert lubricators, oil cups, safety valves, water and cylinder relief valves and metallic specialties for cars and locomotives, including lamps and package racks for cars. The main office and works are at 108 East Dedham St., Boston, Mass.

Mr. Charles A. Moore, of Manning, Maxwell & Moore, sailed on the steamship Columbia of the Hamburgh American line January 9, for Mediterranean ports and Egypt. Mr. Moore is accompanied by his family and the trip is said to be purely one of rest and recreation, and no business is to be connected with it. It is doubtful if a man of Mr. Moore's prominence and individuality could be deterred, while in some of the important continental countries, from visiting the many famous manufactories, iron works and machine shops, and incidentally talking business. We shall probably see some effects of this trip upon the large business interests directed by Mr. Moore.

The New York Air Compressor Company's new shops at Arlington, N. J., commenced operation in all departments but the foundry on January 2, and the company expects to have its foundry at work on February 1. Although organized but a little over sixty days, the sales record of this company is remarkable, orders having been placed with it sufficient to tax its capacity for three months. Plans have been made to double the shop equipment at once, and the plant will be operated day and night until this is done. This company reports sales of over ten air compressors in ten days. These include a large duplex compressor for Japan and four compressors of twelve hundred cubic feet capacity for the Pennsylvania Railroad.

The annual meeting of the Pressed Steel Car Co. was held January 9. The president's report showed that the amount of business for the year 1899 was $13,965,572. This consisted of 9,264 cars, 127,656 bolsters and 50,926 truck frames. The money value of the orders on the books at the first of this year was $16,596,863, which is more than the total for 1899. The net earnings for 1899 were $2,237,104, out of which a 7 per cent. dividend amounting to $875,000 was paid on the preferred stock. A 6 per cent. dividend, amounting to $750,000, has been declared on the common stock; this is payable quarterly during the present year. In addition to these dividends, the sum of $612,103 has been added to the working capital of the company. The orders referred to are to be completed in June, and the present capacity of the works is 100 cars per day. The common stock has earned 11 per cent., in addition to the dividend of $875,000 on the preferred stock, and at this rate the common stock ought to earn over 20 per cent. after providing for dividends on the preferred stock for the year 1900.

An exceedingly convenient gauge for wheels, axles and brake shoes is manufactured and sold by the Youngstown Specialty Mfg. Co. of Youngstown, Ohio. It is designed for the use of car inspectors, car repairers, foremen of engines and others concerned with car and engine trucks. The gauge combines calipers for journals, used without removing the oil boxes (an index finger gives the diameter at a glance), with a gauge for slid flat wheels, one for sharp flanges, one for broken flanges, for worn treads of wheels, for vertical wear of flanges, and for measurement of brake shoes to determine when they are worn to the limit. The gauge is of steel, 1/16 in. thick, and adapted to carrying in the vest pocket. It is made to M. C. B. standard dimensions throughout and is a practical and convenient tool, valuable as a protection to the inspector and repairer as well as to the company employing them. The price is $1, by mail. The gauge was designed and patented by Walter Brainard, of the Lake Shore, Michigan Southern and the Pittsburgh & Lake Erie railroads.